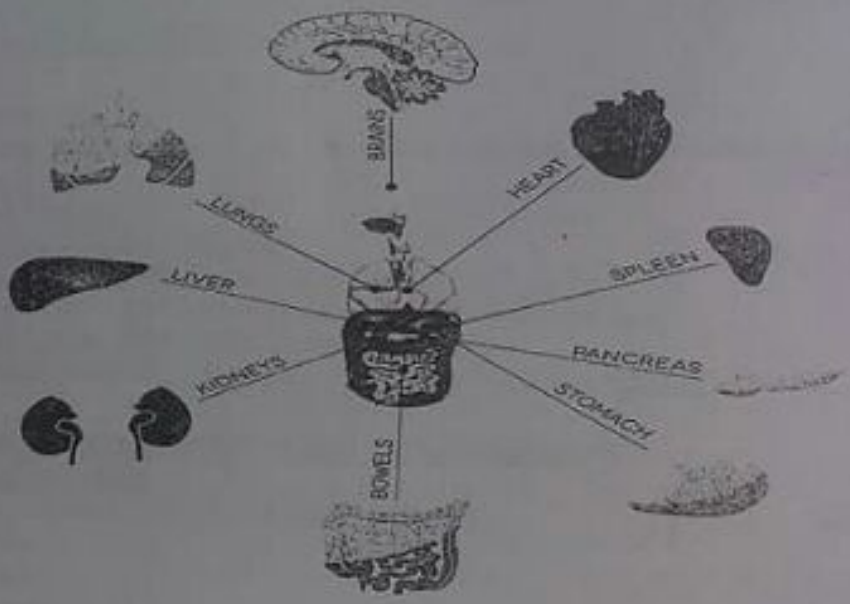
Physiology summary



Prof. Dr.
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Composition of the human body

The body of a normal young adult male weighing 70 kg is composed of:

Water represents about 60% of the body weight (BW).
Other compounds represent about 40% of BW and include:

a) Proteins = 18% of BW.
b) Fats = 15% of BW.
c) Electrolytes= 7% of BW.

Total body Water (TBW)

- TBW represents about 60% of BW in adult males, 50% of BW in adult females, 75% in newborns & 45% in old ages.

Body fluids

TBW is distributed in 2 major body fluid compartments as follows:

1- Intracellular fluid (ICF)

ICF is the fluid that lies inside the cells of the body and it is also called the intracellular compartment.
It represents 2/3 of TBW.

2- Extracellular fluid (ECF)

ECF is the fluid that lies outside the cells of the body and it is also called the extracellular compartment.
It represents 1/3 of TBW.
It is distributed in 2 spaces as follows:

A- Interstitial fluid (ISF) = (Interstitial compartment)
- It is the fluid that lies between cells so it is called the tissue fluid.

B- Intravascular fluid (IVF) = (Intravascular compartment)
- It is the fluid that lies inside vascular system. It is also called plasma.

Types of membrane transport

1-Passive transport include
a) Diffusion (simple diffusion & facilitated diffusion).
b) Osmosis.
c) Filtration.

2-Active transport include
a) Primary active transport
b) Secondary active transport

Composition of blood

1-Plasma (55%)
2-Blood cells (45%)
a) Red blood cells (RBCs) = Erythrocytes = (5-5.5 millions / mm^3).
b) White blood cells (WBCs) = Leucocytes = (4000-11,000 / mm^3).
c) Blood platelets = Thrombocytes = (250,000-500,000 / mm^3).

Classification of Nervous system

1. Central nervous system (CNS).
   A- Brain.
   B-Spinal cord.
2. Peripheral nervous system (PNS).
   A- Cranial nerves.
   B- Spinal nerves.

-Cranial nerves and Spinal nerves are divided into:

a) Sensory nerves.
b) Motor nerves (Somatic nerves and Autonomic nerves).

-Autonomic NS is divided into 2 systems

a) Sympathetic
b) Parasympathetic

Digestive system consists of

1- Gastrointestinal tract (GIT) = Alimentary canal

- It is a muscular tube extends from the mouth to the anus.
- It includes mouth, pharynx, oesophgus, stomach, small & large intestine.

2- Digestive glands

- The secretion of these glands contain the digestive enzymes.
- They are salivary, gastric and intestinal glands, together with the liver and pancreas.

Functions of digestive system include Motility, Secretion, Digestion and Absorption.

Functions of neurons:

a) They receive information from internal & external environment
b) Transmit signals to other neurons & effectors organs

Structure of skeletal muscles

- The skeletal muscles are striated & are made up of hundred muscle fibers.

1- Muscle Fibers

- Skeletal muscles are made up of many muscle fibers (MF) that bundled together by connective tissue (CT).

2- Myofibrils

- The skeletal muscle fibers contain many fibrils (myofibrils) that embedded in the cytoplasm.
- The myofibrils are made of thick and thin myofilaments (contractile proteins).

3- Myofilaments

1. Actin
2. Tropomyosin
3. Troponin

■ Structure of the respiratory system

1- lungs (right and left lobes)

2- Air passage (the respiratory tract).

A-Upper air passage ⇒ formed of nose, nasopharynx and larynx.

B-Lower air passage⇒ formed of trachea , bronchi, bronchioles & alveoli.

3- Pleura

4- Thoracic wall (thoracic cage)

5-intercostals muscles that fill intercostals spaces

■ Structure of Cardiovascular system

1- Heart:

- The heart is a hollow muscular organ

2- Blood vessels:

a) The arteries (elastic vessels).

b) The arterioles (resistance vessels).

c) The capillaries (exchange vessels).

d) The veins & venules (capacitance vessels).

■Functional anatomy of the human heart

- The heart is roughly like a closed man's fist.
- It looks like an inverted cone.
- It is about 300 grams (0.5 % of the body weight) in adult males
- It lies inside the chest cavity

■The wall of the heart

- The wall of the heart consists of 3 layers:
  1. Epicardium (outer layer)
  2. Myocardium (middle layer)
  3. Endocardium (inner layer)

■Chambers of the heart

- 2 superior chambers called 2 atria (right atrium (RA) & left atrium (LA) separated by inter-atrial septum).
- 2 inferior chambers called 2 ventricles (right ventricle (RV) and left ventricle (LV) separated by inter-ventricular septum).

Valves of the heart

Components	Atrio-ventricular (A-V) valves		Semilunar valves	
	Tricuspid valve (T)	Mitral valve (M)	Pulmonary valve (P)	Aortic valve (A)

Arterial blood pressure (ABP)

- It is the lateral pressure exerted by the blood column on the lateral wall of the arteries

Systolic blood pressure (SBP)

- It equals 90-140 mm Hg (average 120 mmHg) in normal adults.

Diastolic blood pressure (DBP)

- It equals 60-90 mmHg (average 80 mm Hg) in normal adults.

Electrocardiogram (ECG)

- ECG is simply record of electrical activity of the heart during each cardiac cycle.

Cardiac output

- Amount of blood pumped by each ventricle per minute and equal 5liters/minute

Endocrine glands

1-Hypothalamus
2-Pituitary gland (ant. & post)
3-Thyroid gland
4-Parathyroid glands
5-Adrenal cortex
6-Adrenal medulla
7-Testes & ovary (gonads)
8-Pancreas

Hormones

- They are chemical substances that are secreted by endocrine glands (ductless gland directly into the blood stream and have a physiological controlling effects on other remo cells of body (target cells)

Male reproductive system

1- Primary sex organ (testis)
- Functions
  a) Spermatogenesis: i.e formation of sperms.
  b) Endocrinal function: synthesis and secretion of male sex hormones e.g testosterone.

2- Secondary (accessory) sex organs

Female reproductive system

1- 1ry sex organ (ovaries):
Functions:
a) Oogenesis: production of ova.

b) Endocrinal function: secretion of female sex hormones e.g estrogen, progesterone, relaxin & inhibin.

2- 2ry (accessory) sex organs:

The urinary system consists of:

a- Two kidneys: form (produce) urine

b- Two ureters, urinary bladder and urethra: transport urine to outside the body

Functions of the kidneys

- Excretion of most waste products of metabolism
  - e.g urea & creatinine, drugs, toxins & excess K+, Na+, H+ or HCO3-

- Reabsorption of essential substances needed by the body
  - e.g glucose & amino acids.

Organization of nervous system

- Sensory division
  - It is concerned with conscious perception of somatic sensations.
  - It includes the sensory receptors, sensory afferents, the sensory ascending tracts, thalamus and sensory cortex.

- Motor division
  - It is concerned with voluntary control of skeletal muscle activity.
  - It includes the motor cortex, the basal ganglia the cerebellum, the motor reticular formation, the motor descending tracts to AHC.

- Integrative division
  - It is concerned with sophisticated functions of the brain like memory, learning, emotion & behavior.
  - It includes association areas of brain & limbic system.

Special senses

- Special senses are 5 highly specialized forms of senses.
- They include:
  1. Vision
  2. Hearing
  3. Smell
  4. Taste
  5. Equilibrium

FACULTY OF APPLIED
MEDICAL SCIENCES
كلية العلوم الطبية التطبيقية

Histology Summary

1. Differences between Mitosis and Meiosis

	Mitosis	Meiosis
1	It is an indirect cell division.	It is a reductional cell division.
2	It occurs in the Somatic cells.	It occurs in testes and ovaries.
3	It consists of one set of mitotic cell division	It consists of 2 sets of divisions, First and Second Meiotic cell Divisions.
4	Before beginning of this division, the cell duplicates its DNA.	4. Before this division, There is no duplication of DNA.
5	It gives 2 daughter cells, each with 46 chromosomes	It gives 4 daughter cells, each with haploid number of chromosomes (23).
6	No crossing over occurs between chromosomes.	Crossing over occurs between homologous chromosomes.

2. Karyotyping

Karyotyping is the study of the number, type and arrangement of chromosomes in the individuals. **Karyotyping is done through the following steps:**

The blood lymphocytes are the most convenient cells for chromosomal studies.

1. From the venous blood of the examined person, a sample of blood is obtained. To prevent clotting of this blood, **a heparin substance** is added to this blood sample.
2. The blood is then **centrifuged** to separate lymphocytes from other blood cells.
3. The lymphocytes are then incubated in a suitable culture medium.
4. **Phytohaemagglutinin** is added to the culture medium to stimulate division.
5. The cultured lymphocytes are incubated for **three days.**
6. We stop cell division of lymphocytes at metaphase by the addition of **colchicine.**
7. The cultured cells are then treated with hypotonic solution.
8. Samples from the cultured cells are then spread on the slides by the drop method.
9. The chromosomes are then fixed, **stained,** examined and photographed.
10. The photographed chromosomes **are cut,** matched into pairs, and individually studied. Now this step is done through the use of **Image Analyzer.**

3. The Clinical Importance of Chromosomal Studies

1. **Chromosomal studies** help in diagnosis of certain diseases and syndromes as: Down syndrome (mongolism) and mental retardation.
2. Diagnosis of primary amenorrhoea, repeated abortions and infertility.
3. Diagnosis of certain malignant diseases as chronic myeloid leukaemia.
4. Karyotyping of foetal cells helps in prenatal diagnosis of certain diseases and in determination of the sex of the foetus (either male or female).

4. TYPES AND FUNCTION OF CHROMATIN

There are two types of chromatin; Euchromatin and Heterochromatin:

a) **The Euchromatin or Extended Chromatin or Active Chromatin:**
   - They represent **the extended (uncoiled)** parts of the chromosomal thread.
   - They are the **most active chromatin.**
   - They control **protein synthesis.**

b) **The Heterochromatin or Condensed Chromatin or the Inactive Chromatin:**
   - They appear as dark masses of nucleoprotein.
   - The condensed chromatin are **inactive.**
   - They **do not** direct any protein synthesis.
   - The Heterochromatin is distributed within the nucleus as:
     - **Peripheral chromatin**: attached to the inner nuclear membrane.
     - **Nucleolus-associated chromatin**: around the nucleolus.
     - **Chromatin islands:** scattered in the nuclear sap in the form of clumps of irregular size and shape.

○ **Functions of Chromatin:**

i. It controls protein synthesis inside the cell.
ii. It stores the genetic information of the individuals.

5. GLANDS

The glands are classified according to presence or absence of ducts, into:

i. **Endocrine or ductless glands, secreting hormones directly in the blood** as: Thyroid, parathyroid, pituitary, suprarenal, pineal body, placenta, and special cells in the testis and ovary.

ii. **Exocrine glands: They have ducts to carry their secretions. e.g. salivary glands, sweat and sebaceous glands.**

iii. **Mixed glands: which possess the exocrine and endocrine functions as: pancreas, testis and ovary.**

6. MAST CELL

◊ ***Site and origin:*** It is present in loose C.T. along the blood vessels. It is derived from UMC or from the pericyte.

◊ ***Structure:***

L/M: *oval* to round cell,
cytoplasm is filled with basophilic granules which can be stained metachromatically (they take a different color than of the dye used e.g. they stained reddish purple with toluidine blue)
Nucleus: *is* masked by the cytoplasmic granules.

◊ ***Function:***

a- Heparin secretion: Heparin acts as an anticoagulant.
b- Histamine release in allergy, in certain individuals with hypersensitivity is exaggerated, leading to excessive histamine release resulting in allergy.
c- Production of other chemical mediators as:

- Slow reacting substance of anaphylaxis (SRSA).
- Esinophil chemotactic factor of anaphylaxis (ECFA).

7. CARTILAGE CELLS

◊ **Chondroblasts**
- They are flat cells with flat nuclei. They can divide.
- Their cytoplasm is basophilic, it contains all organelles needed for protein synthesis as RER, ribosomes and well developed Golgi apparatus.
- They are present mainly under the perichondrium.
- They form the protein and type II collagen of the cartilage matrix.

◊ **Chondrocytes**
- They are oval or rounded cells with rounded nuclei.
- Their cytoplasm is basophilic, it contains organelles required for protein synthesis. It is rich in gycogen, fat and phosphatase enzymes.
- Chondrocytes can divide, they are present in groups called Cell Nests.
- The groups of cartilage cells are surrounded with a space called lacuna, outside this lacuna the matrix is condensed to form the **capsule** of cell nest.

Function of Chondrocytes:

i. They form the matrix.
ii. They are responsible for the interstitial growth of cartilage

8. OSTEOCLAST CELLS

◊ **Origin:** They originate from the circulating **blood monocytes.**
◊ **It** is a large cell with irregular cell membrane.
◊ **Each** cell contains from 4 to 50 **nuclei.** — Each cell is about **150 microns** in diameter.
◊ **The** cytoplasm of osteoclast is **acidophilic** and is rich in acid phosphatase enzymes.
◊ Osteoclasts secrete osteolytic enzymes which destroy bone matrix, therefore, they are surrounded by spaces called **"Howship's lacunae".**

Osteoclast

◊ Sites: They are present in bone marrow cavities and endosteum of bone.
◊ Functions **of Osteoclasts**
a. They are concerned in bone resorption during ossification.
b. They secrete **Enzymes** that dissolve bone matrix during ossification.
c. They secrete acids which play a role in decalcification of bone matrix.
They remove bone debris during ossification. They are bone eating cells.

9. DIFFERENCES BETWEEN CARTILAGE AND BONE

Bone	Cartilage
1. It is a solid inflexible tissue.	1. It is a rigid flexible tissue.
2. There are 2 types of bone: compact and spongy (cancellous).	2. There are three types of cartilage: Hyaline, elastic and white fibro cartilage.
3. It has a solid matrix rich in calcium.	3. It has a rigid matrix rich in chondroitin sulphuric acid and glycoprotein.
4. Bone cells (osteocytes) are present singly inside lacunae.	4. Cartilage cells (chondrocytes) are present singly or in groups inside lacunae forming cell nests.
5. Osteocytes intercommunicate by the canaliculi arising from their lacunae.	5. Chondrocytes do not communicate because there are no canaliculi.
6. Bone is a vascular tissue, its Haversian canals, Volkmann's canaliculi and canal carry blood to all parts of bone.	6. Cartilage is a non - vascular tissue but its chondrocytes receive nourishment from B.V. of the perichondrium.
7. Osteocytes cannot divide.	7. Chondrocytes can divide.

10. CAUSES AND TYPES OF ANEMIA

1. **Deficiency Anemia:** deficiency of these elements may result in anemia: iron, copper, proteins, hormones, vitamin C and vitamin B12.
2. **Haemorrhagic Anemia:** as haemorrhage from nose, gums, piles and wounds.
3. **Haemolytic Anemia:** when there is an excessive destruction of RBCs as in certain congenital abnormalities of the cell membrane as in Spherocytosis; OR deficiency of enzymes as in Favism; OR Presence of haemoglobin F as in Thalassemia, OR presence of haemoglobin S as in Sickle cell anemia.
4. **Aplastic Anemia:** When the bone marrow (in which RBCs are formed) is congenitally abnormal, or if it is partially destroyed by X-ray or by antibiotics.

11. DIFFERENCES BETWEEN RBCS AND LEUCOCYTES

	RBCs	Leucocytes
1	Average **number:** from 4.5 to 5.5 5.5 millions per cubic millimeter.	Number : from 4000 to 11.000 per cubic millimeter.
2	They are of **one** type.	They are of 5 types.
3	They are **corpuscles** = not true cells.	They are true cells.
4	They have no nuclei and no cell **organoids.**	They contain nuclei and cell **organoids.**
5	They have no movements.	They have an amoeboid movement.
6	They are biconcave corpuscles.	They are spherical cells.
7	They appear in rouleaux.	No rouleaux appearance.
8	**Color:** greenish yellow.	They are colourless.
9	**Diameter** 7.5 microns.	Diameter from 8 to 18 microns.
10	They are easily haemolysed.	They resist haemolysis partially.
11	They contain haemoglobin.	They have no haemoglobin.
12	They carry oxygen and Co2 while they are inside the B.V.	They are phagocytic cells but outside the B.V.
13	They develop in the red marrow.	They develop in red bone marrow and in the lymphatic tissues.
14	Life span about 4 months.	Life span from few days to years.

12. DIFFERENCES BETWEEN SKELETAL, CARDIAC AND SMOOTH MUSCLES

	Skeletal	Cardiac	Smooth
	Voluntary & striated.	Involuntary & striated.	Involuntary& non striated.
Site	skeletal muscles, tongue	Myocardium of the wall of the heart.	Walls of blood vessels and viscera.
The fiber	is a long cylindrical cell.	Formed of a chain of short cylindrical cells.	Short fusiform single cell.
	Do not branch except in tongue and face.	Branch and anastomose.	Do not branch.
Diameter	Thickest (10 -100µm) **Length of fiber:** 1- 30mm.	Thinner (20-25gm).	Thinnest (up to 6m).
		From 35- 100µm .	Varying from 20µm to V2 mm.

Nuclei per cell	multiple flat&peripherl.	Single Oval & central.	Single Road-shaped & central.
Striations	distinct.	Less distinct.	Absent.
Myofibril	Regular sarcomeres.	Less regular & branching.	Irregularly arranged (no sarcomeres).
Triad	distinct.	Dinds.	Absent.
T tubules	thin.	Thick.	Absent (replaced by caveolae).
Intercalated discs	absent.	Present, show desmosomes & nexuses.	Absent.

13. DIFFERENCES BETWEEN SPINAL AND SYMPATHETIC GANGLIA

	Spinal Ganglia	Sympathetic Ganglia
1	Present mostly at the dorsal roots of the spinal cord.	Present mostly at the sympathetic chain.
2	Covered by thick C. T. capsule.	Covered by thin C. T. Capsule.
3	Formed of pseudo-unipolar nerve cells.	Formed of multipolar stellate shaped nerve cells.
4	The cells may be large or small (20-120 microns).	All the cells are mostly of the small size (30 microns).
5	The cells are arranged in groups	The cells are scattered. (not present in groups
6	The groups of cells are separated by myelinated nerve fibers.	The nerve cells are separated by non-myelinated nerve fibers.
7	The cells are rounded in shape in cross section.	The cells are irregular in shape in cross section.
8	Each ganglion contains few nerve cells.	Each ganglion contains many nerve cells.
9	The axon of each nerve cell is convoluted at its beginning in the nerve cell forming a glomerulus in its cytoplasm.	There is no intra cellular glomerulus Because the nerve cells are multipolar and their axons are not convoluted.
10	Thereare more satellite cells around each nerve cell.	Less number of satellite cells around each nerve cell.
11	There is no synapse between the neurones.	Synapse is present between the neurones.
12	It is poor in blood supply.	It is rich in blood supply.

14. COMPARISON BETWEEN MEDIUM-SIZED ARTERY AND VEIN.

Medium-sized artery	Medium-sized vein
Thick wall and narrow lumen.	Thin wall and wide lumen.
Well-developed muscular and elastic tissue.	Poorly developed.
The tunica intima is thick.	Thin.
The internal elastic lamina is well developed.	No I.E.L.
The tunica media is thick, rich in elastic fibers.	Thin, poor in elastic fibers.
The tunica adventitia is thinner than media.	Adventitia is thicker than media.
The wall is not collapsed and the lumen has no blood after death.	collapsed and the lumen contain blood after death.
No valves are present in its lumen.	Valves are present.
Rapid flow of arterial blood.	Slower flow of venous blood.
External elastic lamina may be present.	No E.E.L.

MICROBIOLOGY

Microbes that cause infectious diseases

The agents of human infectious diseases belong to five major groups of organisms: bacteria, fungi, protozoa, helminths, and viruses. The bacteria belong to the prokaryote kingdom, the fungi (yeasts and molds) and protozoa are members of the kingdom of protists, and the helminthes (worms) are classified in the animal Kingdom.The protists are distinguished from animals and plants by being either unicellular or relatively simple multicellular organisms. In contrast, helminths are complex multicellular organisms. Taken together, the helminths and the protozoa are commonly called parasites. Viruses are quite distinct from other organisms, they are not cells but can replicate only within cells

Major groups	Prokaryotes (bacteria)	Eukaryotes (fungi, protozoa, plant, animal)
Size	Small cell (< 10μm)	Larger cells (> 10 μm)
Nucleus	No nuclear membrane	Classic membrane
Chromosome	Haploid, single DNA circular, without proteins	Diploid genome; multiple DN linear and associated with proteins to form chromatin.
Mitochondria	Absent	Present
Golgi bodies	Absent	Present
ER	Absent	Present
Ribosome	Small 70S (50S+30S)	Large 80S (60S+40S)
Cytoplasmic membrane	No sterols except Mycoplasma	Contains sterols
Cell wall	Peptidoglycan	Absent (animal) or with chitin, cellulose
Cell division	Binary fission	Meiosis and mitosis
Movement	rigid rotating flagellum composed of flagellin	flexible waving cilia or flagella composed of tubulin
Respiration	On cytoplasmic membrane	Via mitochondria

Microscopic Identification of bacteria

By microscope after staining by

→ **1-Simple stain**

→ **2-Gram stain**

-If Gram **positive** bacteria →bacteria appear **violet** under microscope

-If Gram **negative** bacteria →bacteria appear **red** under microscope

→ **3- Special stain (e.g. Acid fast stain** as in *Mycobacteria*).

Structure of bacteria

Bacterial Cells have a nucleus or nucleoid, which contains DNA; this is surrounded by cytoplasm, within which proteins are synthesized and energy is generated. Viruses have an inner core of genetic material (either DNA or RNA) but no cytoplasm, and so they depend on host cells to provide the machinery for protein synthesis and energy generation.

Essential structures include	Non- essential structures include
- Cell wall - Cytoplasmic membrane - Nucleoid and DNA - Ribosomes	- Capsule-Glycocalyx - Flagella - Pili - Plasmid - Food granules - Spores

Antimicrobial Chemotherapy

-Chemotherapy is the use of drugs to treat a disease. Antimicrobial drugs interfere with the growth of microbes within a host.

-Chemotherapeutic agents: synthetic drugs with antimicrobial activity

Antibiotics: are compounds of natural, semi-synthetic or synthetic origin which inhibit growth of microorganisms without significant toxicity to the human or animal host.

-Bactericidal agents: drugs which kill and destroy the bacteria.

-Bacteriostatic agents: drugs which inhibit the growth and multiplication of bacteria without killing them.

-Spectrum of activity: Range of effect within or between groups of microbes; narrow vs. broad-spectrum

Characters of ideal antimicrobial agents:

1- **Selective toxicity:** harmful to the bacteria and non toxic to the host cells.

2- **Therapeutic index**: ratio between toxic dose and therapeutic dose. High therapeutic index ⇒ less toxic.

3- **Broad spectrum:** affect a variety of bacteria both Gram positive and Gram negative.

4- **Bactericidal** better than bacteriostatic.

5- **Diffusible** to distant body areas with slow rate of excretion.

6- Bacteria **do not develop resistance** to it.

Mechanisms of action of antibacterial agents

1-Inhibition of cell wall synthesis: penicillin, cephalosporin and vancomycin.

2-Inhibition of cell membrane function: polymyxins, amphotericin-B, nystatin and colistin.

3-Inhibition of protein synthesis: chloramphenicol, tetracycline.

4- Inhibition of nucleic acid synthesis:

-DNA inhibition by inhibiting DNA gyrase enzyme: quinolones.

-RNA inhibition by inhibiting RNA polymerase enzyme: rifampicin.

5-Competitive inhibition: sulphonamides compete with para-amino-benzoic acid (PABA) for the active site of the enzyme involved in folic acid synthesis.

Complications of antimicrobial chemotherapy

1-Drug toxicity: due to over dosage, prolonged use or narrow margin of selective toxicity. Chloramphenicols cause bone marrow inhibition.

2-Hypersensitivity:

- Some antimicrobials act as haptens. When they bind to host tissue proteins, they become antigenic and stimulate exaggerated immune response leading to tissue damage.

3-Superinfection:

- During treatment with a broad spectrum antibiotic, susceptible members of normal flora at different body sites are killed. This will result in biological imbalance. Oral Candida may cause thrush or vaginitis. *Clostridium defficile* and staphylococci cause enterocolitis.

4-Development of drug resistance:

Chemoprophylaxis: Means administration of antimicrobial drugs to prevent infection (before the development of a disease).

Examples:

1-A single large dose of amoxycillin given immediately before dental procedures for patients with congenital or rheumatic heart disease to prevent endocarditis.

2- Oral rifampicin 600 mg twice a day for 2 days during epidemics of meningococcal meningitis.

Sterilization and Disinfection

Cleaning: A process that physically removes contamination and many microorganisms using detergent

Sterilization: This is the destruction of infectious agents (including spores) from an environment. This includes bacteria, fungi, protozoa, viruses, spores and poorly characterized agents such as viroids.

Disinfection: Reduces the number of micro-organisms to a level at which they are not harmful. Spores will not usually be destroyed.

Antisepsis: Is the disinfection of living tissues; through the use of antiseptics. In general, antiseptics are less harsh in their action than are disinfectants, many of which are toxic to humans.

Methods of Sterilization:

- **I-Physical methods:**
  1- Heat (dry heat and moist heat).
  2- Radiation (ionizing radiation and UV rays).
  3- Filtration
- **II-Chemical (gaseous and liquid)**

I: Physical means of sterilization

1-Dry heat

** It is a physical oxidation or slow burning process to oxidize the essential components in cells

** Dry heat is less effective than moist heat

** It is used to sterilize delicate metal instruments that would be eroded if exposed to steam , reusable glass syringes, and ointments, powders, oils etc…

Advantages of dry heat

- Hot air penetrates certain substances that cannot be steam or gas sterilized.
- Can be used in laboratories to sterilize glassware.
- It is a protective method of sterilizing some delicate, sharp, or cutting edge instruments. Steam may erode or corrode cutting edges.

2- Moist heat

- Denaturation and coagulation of protein or the enzyme-protein system within cells. These reactions are catalyzed by the presence of water.

Methods:

A- Moist heat at temp. below than 100C:

1- **pasteurization:** as pasteurization of milk by heating at 63 ℃ for 30 min. or at 72 ℃ for 20 sec. and immediately cool below 10 ℃

- This kills non- spore forming milk borne pathogens e.g. *M.tuberculosis*, *Br abortus* and Salmonella.

2- **Vaccine bath:** Heating at 60 ℃ for 1 hr, used for sterilization of vaccines.

3- **Water bath:** heating at 56 ℃ for 1 hr for 3 successive days. Used for sterilization of serum and body fluids (contain protein destroyed by heat).

4- **Inspissation:** Heating at 85 ℃ for 30 min. for 3 successive days.

- used for sterilization of media containing egg and serum e.g. L.J and dorset egg.

B-Moist heat at temp of 100°C:

1 Boiling at 100 °C:

-Boiling occurs at 100°C for 20 min. and enhanced by adding 2% Na bicarbonate

-Kills all vegetative bacteria, HBV and mycobacteria but not spores.

-Used for surgical and medical equipment when sterility is not required

2-Steaming at 100°C: (Koch steamer):

It is done in steamer or Koch's sterilizer which is vertical metal cylinder with a removable conical lid, having a small opening for the escaping steam. Water is boiled and the rising steam will sterilize the articles.

C- Moist heat at temp. more than 100°C: (autoclaves)

Principle: When heating wear in a closed vessel, boiling point rises above 100°C.

Conditions of sterilization: Heating at 121°C under 2 atmospheric pressure for 20-30 min. or at 134°C under 3 atmospheric pressure for 3-6 min. (flash autoclave)

Autoclaving is the most efficient method of sterilization. Why?

1- High temp. 2- High penetration power of steam under pressure.

3- Condensed steam liberates large amount of latent heat. 4 - Not toxic,

Radiation

A-ionizing radiation:

- Gamma rays (emitted from radioactive cobalt 60) and β rays (produced by electron accelerator). - Have high penetration power

B-Ultra violet radiation

- Present in sun rays & artificially produced by mercury lamps.

- Have weak penetration power.

Filtration

- It is a mechanical method for exclusion of organisms from **biological fluids** which are destroyed by heat e.g. serum, plasma, hormones, vitamins and fluid culture media.

II: Chemical means of sterilization

Gaseous sterilization — **liquid disinfectants**

A- Gaseous sterilization

1- Ethylene oxide (EO) It is highly effective disinfectant, capable of killing spores rapidly by interfering with the normal metabolism of protein and reproductive process. Used for heat sensitive instruments: plastics, suture material, lenses and finely sharpened instruments

2-plasma gas sterilizer

- Hydrogen peroxide is activated to create a reactive plasma or vapor. - Free radicals of the hydrogen peroxide interact with cell membranes, enzymes, or nucleic acids to disrupt life functions of microorganisms.

B-liquid disinfectants

1-**Ethyl**: Exposure time is 5 min. inactivated by presence of inorganic materials

2- **Phenols:** disinfectant, used to decontaminate culture and clean floors, not inactivated by organic materials

3- **Chlorine:** Hypochlorite (house hold bleach): disinfect floors table tops, incubators, and spilled media Chlorine: disinfect water supply and swimming pools

4- **Iodine:** skin antiseptic e.g. betadine.

5- **Hydrogen peroxide:** antiseptic for cleaning wounds and disinfection of contact lenses and some endoscopes.

6- **Glutaraldehyde 2% (cidex):** for instruments can't withstand heat e.g. endoscopes, dialysis system.

7- **Peracetic acid:** used in sterilization of endoscopes and laparoscopes (highly lethal to bacteria including spores).

8- **Heavy metals**: e.g. mercury (mercurochrome) and silver (silver nitrate)

9- **Chlorhexidine:** antiseptic used in hand wash and oral hygiene.

10- **Quaternary ammonium compounds:** e.g. savlon. Cleaning detergents for floor, furniture and walls.

FACULTY OF APPLIED
MEDICAL SCIENCES
كلية العلوم الطبية التطبيقية

Biophysics Summary

Chapter 7

MEDICAL LASER APPLICATIONS

Laser technology is one of the most rapidly developing areas in modern technology.

When the laser was invented, in 1960, it was classified as a *solution in search of a problem*, and today laser technology is applied in many different areas such as: daily use, communication, medicine, industry and military. To explain how the laser can be applied in such diverse areas, we need to understand the basic physical principles of the operation of a laser.

In principle, the laser is a device which emits electromagnetic radiation through a process called *stimulated emission*. This is a very general definition, but it helps to understand the basic physics of the laser.

The word *LASER* and is an acronym for *light amplification by stimulated emission of radiation*. The word *light* in this phrase is used in the broader sense, referring to electromagnetic radiation of any frequency, not just that in the visible spectrum. Hence there are *infrared lasers*, *ultraviolet lasers*, *X-ray lasers*, etc. Because the microwave equivalent of the laser, the *maser*, was developed first, devices that emit microwave and radio frequencies are usually called *masers*. The energy put into the laser can be in any form such as electromagnetic radiation, electrical energy, chemical energy, etc

Lasers are sources of light with very special properties. For that reason, there is a great variety of laser applications. Those laser applications in medicine include: Surgery, Diagnostic, Photo Dynamic Therapy.

Properties of Laser Radiation

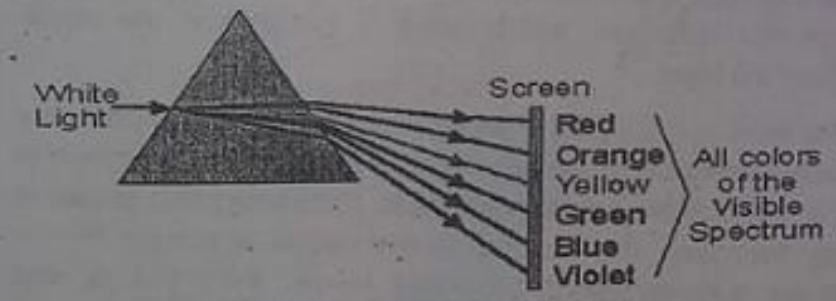
"Ordinary light" (from the sun or lamps) is composed of many different wavelengths, radiating in all directions, and there is no phase relation between the different waves out of the source.

Laser radiation is characterized by certain properties which are not present in other electromagnetic radiation:

1. **Monochromaticity**.
2. **Directionality**.
3. **Coherence**.

1. Monochromaticity

Monochromaticity means "One color". To understand this term, examine "white light" which is the color interpreted in the mind when we see all colors together. When "white light" is transmitted through a prism, it is divided into the different colors which are in it.



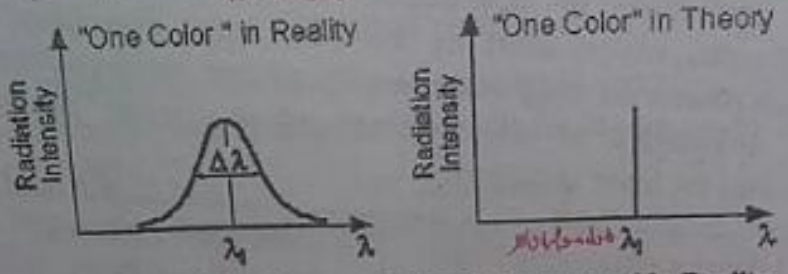
White light passing through a prism

The Meaning of "One Color"

In the theoretical sense **"One Color"**, which is called **"spectral line"**, means **one wavelength** (λ_0).

A graph of light intensity versus wavelength for ideal "one color" is shown on the right side of figure 1.7.

The right side of figure 1.7 shows an artistic description of realistic "one color". It has a peak of its value of "the color", but include a spread around the central peak. In reality, every spectral line has a **finite spectral width** ($\Delta\lambda$) around its **central wavelength** (λ_0).



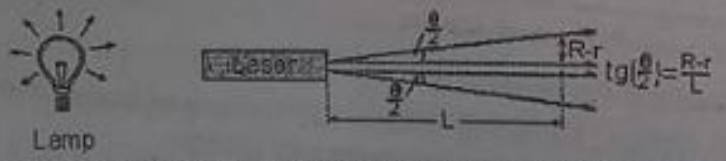
Bandwidth of laser radiation in Theory and in Reality

2. Directionality

Radiation comes out of the laser in a certain direction, and spreads at a defined **divergence angle** (θ) (see figure 1.8, and example 1.2).

This angular spreading of a laser beam is very small compared to other sources of electromagnetic radiation, and described by a **small divergence angle** (of the order of **milli-radians**).

In figure 1.8, a **comparison** is made between the radiation out of a laser, and the radiation out of a standard lamp.

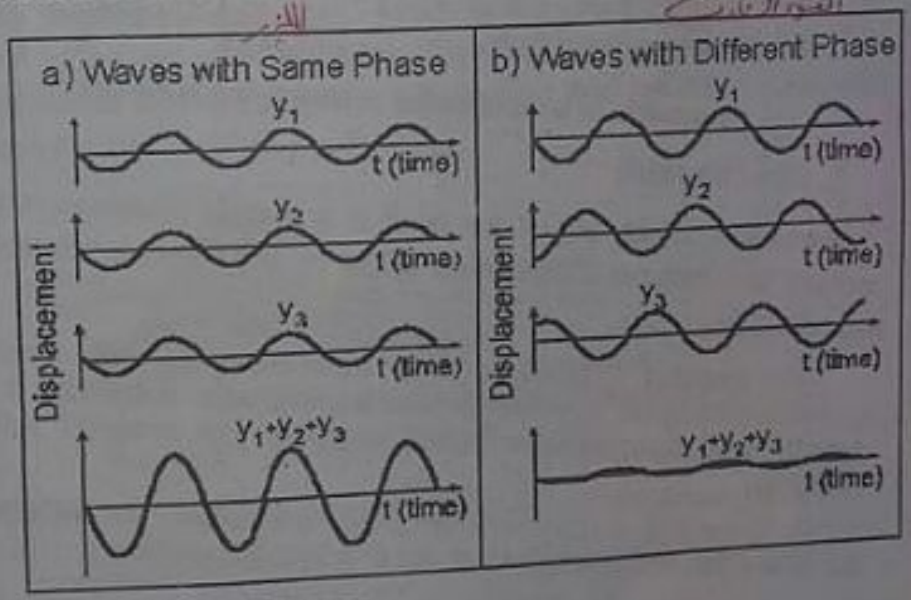


comparison between the light out of a laser, and the light out of an incandescent lamp

3. Coherence

Since **electromagnetic radiation** is a wave phenomena, every electromagnetic wave can be described as a sum (**superposition**) of sine waves as a function of time.

Light from an incandescent lamp is composed of waves at many wavelengths, and each wave appears randomly with no systematic relation between its phase and that of the other wave. **Laser radiation is composed of waves at the same wavelength, which start at the same time and keep their relative phase as they advance.** By adding (superposition) the wave amplitudes of the different waves, higher peaks are measured for laser radiation.



Superposition of waves

Medical Applications

There are many medical applications of lasers, and there are different ways to classify them into **groups**:

- According to the organ to be treated by the laser, such as: Eye, General Surgery, Dentistry, Dermatology, Blood vessels, Cardiac, etc.
- According to the type of laser used for treatment, such as: CO_2, YAG, and Argon.
- According to the type of treatment, such as diagnostic, surgery, connecting blood vessels.

The classification used here is basically according to the type of treatment, with comments on suitable lasers used for each application:

1- **Lasers in medical surgery.**

2- **Lasers in diagnostic medicine, and in combination with drugs.**

3- **Lasers for specific applications: Soft lasers.**

When using lasers for medical treatments, a good understanding of the **interaction between specific laser radiation with specific biological tissue** is required.

Interaction between Laser Radiation and Biological Tissue

The interaction between electromagnetic radiation and biological tissue depends on:

1. The **wavelength** of light, which determines the energy of each photon of light.
2. The **intensity** of radiation.
3. The **shape** of irradiation (continuous or pulsed).

For power levels is up to few Watts, the interaction is divided into 3 regions of wavelengths:

1. **Short UV region** - the photons interact with the proteins, RNA and DNA, and usually kills the biological cells.
2. **Near UV and Short visible range - photochemical reactions** such as **photosynthesis**. Especially with the Excimer laser.
3. **Visible and Near Infra-Red region - Thermal effects** due to absorption of the radiation.

Optical Processes

The parameter that summaries the effects of laser radiation on biological tissue is **Fluence:**

Fluence = (Watt * time)/Spot Size

When a laser beam hits matter, 4 processes can take place:

- **Reflection** - according to the law of reflection: The reflected angle is equal to the incidence angle.
- **Scattering** - laser energy is scattered to all directions.
- **Transmission** - laser beam pass through the material.
- **Absorption** - laser beam is absorbed by the material.

Only the last process (Absorption) can transfer energy to the material. Thus, causing a rise in temperature or chemical reaction.

The effects of the laser beam on the biological tissue can be:

- **Thermal effects** - Produce by most continuous wave lasers such as CO_2, YAG and Argon. The laser energy is absorbed by the biological tissue, raise the local temperature, so the tissue can be ablated, vaporized, coagulate, or cut.

- **Mechanical effects** - Especially when **short pulses of high power laser** is used to create a "blast" by heating a small region of tissue to high temperature in a very short time. The blast creates a **shock wave** that disrupts the tissue near by. This effect is used in eye treatment for disrupting posterior capsule in secondary cataract.
- **Chemical effects** - Used in **Photo-Dynamic Therapy (PDT)** and in Excimer laser applications such as **reshaping the cornea.**

Changes in biological tissue as a result of laser action:

Thermal Changes:

Depending on the temperature, many kinds of changes can occur in the biological system:

- Body temperature till 60^{0}C: Tissue becomes worm, and it is possible to weld blood vessels.
- 60-65^{0}C: **Coagulation.**
- 65-90^{0}C: **Protein Denaturization.**
- 90-100^{0}C Elimination of fluids (Drying).
- 100+^{0}C: **Vaporization and carbonization.**

The Advantages of Laser Surgery:

- **Dry field of surgery**, because laser energy seals small blood vessels.
- **Less postoperative pain**, because of the sealing of nerve ends.
- No contact with mechanical instruments, so **sterilization** is built in.

- **Clear field of view**, because no mechanical instrument blocks it.
- Possible **wavelength specific reaction** of specific colors of biological tissue.
- Possibility to perform **microsurgery under a microscope.** The laser beam passes through the same microscope.
- Possibility to **perform surgical procedures inside the body without opening it**, using optical fibers to transmit the laser beam.
- The laser can be used as a **precise cutting tool.**
- It can be **controlled by a computer**, and operate with a very small area of effect **under a microscope.**

1 Lasers in Medical Surgery

Almost every medical surgery in which a **removal of tissue** is required or a **cut needs to be made**, can be done with a laser.

In general, the results of surgery using lasers are better than the results using a surgical knife.

The Advantages of Laser Surgery:

- **Dry field of surgery**, because laser energy seals small blood vessels.
- **Less postoperative pain**, because of the sealing of nerve ends.
- No contact with mechanical instruments, so **sterilization** is built in.
- **Clear field of view**, because no mechanical instrument blocks it.

- Possible **wavelength specific reaction** of specific colors of biological tissue.
- Possibility to perform **microsurgery under a microscope.** The laser beam passes through the same microscope.
- Possibility to **perform surgical procedures inside the body without opening** it, using optical fibers to transmit the laser beam.
- The laser can be used as a **precise cutting tool.**
- It can be **controlled by a computer**, and operate with a very small area of effect **under a microscope.**

Medical Surgery Fields

The areas of medical laser surgery are well established, and include:

- **Eye Treatment.**
- **General Surgery.**
- Ear, Nose and Throat.
- **Dentistry.**
- **Dermatology.**
- Gastroenterology and colo-rectal.
- **Plastic surgery.**
- Gynecology.
- Urology.
- Oncology.
- Orthopedics.
- Neurosurgery.
- Veterinary.
- Cardiovascular.

Medical Centers

Because of the high cost of the laser instruments, many places in the world established **Laser Centers**, in which many doctors are using the facilities around the clock.

Lasers in General Surgery

Almost every medical surgery in which a removal of tissue is required, or a cut needs to be made, can be done with a laser. In general, the results using lasers are better than the results using a surgical knife.

- When a **bleeding need to be stopped**, a **Nd-YAG laser** can be used. Its radiation enters deep into the tissue, and heats and coagulates a large area.
- When a **clean cut** need to be done, an **Excimer laser** is used.
- A more **general cutting tool** is the **CO_2 laser**

Special Applications of lasers in General Surgery:

Snoring Treatment

Nd-YAG Laser for medicine:

Most **applications of continuous wave Nd-YAG laser in medicine** were to heat a big volume of tissue to high temperature. Thus, **stopping hemorrhage** by sealing blood vessels.

Advantages of Nd-YAG laser for Medicine:

One of the main advantages of Nd-YAG laser for medicine is the **possibility to transmit high power of its radiation (at about 1 [μm] wavelength) through quartz optical fibers**.

This enables performing procedures inside the human body without the need to open it first. The fiber can be inserted through the body openings (such as mouth or rectum), or through a small incision, and guided using medical endoscope.

With the invention of synthetic **Sapphire tips at the end of optical fibers**, a new area of **contact surgery** using Nd-YAG laser was opened to medical doctors.

The idea is to conduct the Nd-YAG laser radiation through an optical fiber, which ends with a Sapphire tip of specific shape.

For each application, a different type of Sapphire tip end is used:

- A **scalpel shaped tip** enable cutting, and immediate coagulating with the Nd-YAG laser radiation coming out of the tip directly into the cut area.
- **Rounded or Flat-surfaced tips** distribute the Nd-YAG laser radiation on a large area.
- **Special frosted tips** are used to cut and coagulate at the same time.

CO_2 Laser for medicine:

The Infra-Red (IR) wavelength of the CO_2 laser (10.6 [μm]), is **highly absorbed by water.**

Since biological tissue contains 75-90% water, the CO_2 laser beam is absorbed in a very thin layer of the tissue. If the time of interaction is short, no more than 0.1-0.2 millimeter of tissue are influenced by the laser beam.

When a **focused CO_2 laser beam** is used for cutting, the cut has very little effects on surrounding tissue.

When an **unfocused CO_2 laser beam** is used for surface vaporization, it ablate thin layers, one after the other, with no damage to underlying structures.

One of the main **disadvantages** of CO_2 laser for medical surgery is the **unavailability of good optical fibers that can transmit high power beam at wavelength of about 10 [μm]** to organs inside the human body.

Lasers in Dentistry

Dental laser applications are divided between the **soft tissue** and the **hard tissue** (the teeth).

Dental soft tissue treatment applications are similar to those of other soft tissue in the body, and are common for many years.

- In case of **gum surgery**, with the laser most of the patients suffer less postoperative pain.
- Almost no bleeding.
- No stitches required.

Dental hard tissue treatment is new, and only in May 1997 the **FDA (Federal Drug Administration)** approved the Er-YAG laser for use on the hard tissue (teeth) in humans.

Compared to the mechanical "conventional" dental drill, the **laser operates without the noise and the mechanical pressure on the treated tissue.**

Lasers in Dermatology

Lasers can remove almost all the defects on the skin. Sometimes the laser is the only instrument to perform specific procedure.

Most dermatological procedures are done in an **outpatient clinic**, under **local anesthesia.**

The **American Society for Dermatological Surgery** has a Web site at:

Among these defects are:

- **Pigmented skin, Abnormal skin growth, Blemishes.**
- **Tattoos**. Today, with the wide variety of lasers in use, tattoos can almost completely be erased from the skin. Different wavelengths are used to remove different ink colors from the skin. The specific laser wavelength is **selectively absorbed by the specific color, without damage to surrounding cells**. Usually the treatment is made in a number of treatments. After each treatment checking what was left in the damaged skin.

A nice Web site about the laser tattoo removal is at **Beckman Laser Institute and Medical Clinic:**

- **Carcinomas and malignancies.**

The main advantages of lasers for dermatology are:

- Almost no bleeding.
- Almost no scars left after removal of defects.

The lasers used mostly for the skin are:

- **Argon laser** - highly absorbed by pigmentation and melanin (dark tissue). Used for treating vascular lesions. Penetrates the skin 0.5-2 [mm].
- **Dye laser** - Mostly used because of the **tunability** of the wavelength, which can be adapted to the organ to be removed. The specific wavelength which has maximum absorbance in the defect tissue can be chosen, while at the same time has low absorbance in normal tissue.

- CO_2 laser.

Skin resurfacing

Among the cosmetic applications of the laser, the **skin resurfacing** is a very promising one.

More information aboutt this procedure can be found at:

Lasers for eye treatment

The laser was invented in 1960, and in 1961 this laser (Ruby) was used by eye doctors.

It is natural that the eye was chosen to be the first organ for performing medical experiments, since the **eye is transparent to the electromagnetic spectrum in the visible range.**

Another natural device that helps was the **lens in the eye,** which focuses the electromagnetic radiation onto the retina. Thus, increasing the power density by orders of magnitude.

Soldering Detached Retina

The first application of laser for medical applications was for experiments in **soldering detached retina** in animals. As a result of mechanical shock, the retina inside the eye can be torn, and detached from the tissue .

The electromagnetic radiation from the laser heats the detached retina, and as a result the damaged blood vessels around the retina are closed and solder to place.

In 1964 first experiments were done on human subjects, and today it is a standard treatment.

Because of the **focusing effect of the eye,** small amount of laser power is needed to solder the detached retina.

Actually electromagnetic radiation was used for this purpose for many years, starting with the middle ages where the doctors used radiation from the sun for this purpose.

Excimer lasers for Eye Surgery

Most of the change of direction (refraction) of light rays entering the eye is performed by the cornea, since the light goes from air (index of refraction about 1) to the tissue (index of refraction about 1.3).

For a more detailed explanation, **see Snell Law.**

Thus, **a small change in the radius of curvature of the cornea causes a big change in the focusing of light in the eye.**

Radial Keratotomy

The first medical treatments for **changing the curvature of the cornea** were done by cutting tiny surgical incisions along the radius of the cornea. Using a diamond bladed knife, few cuts were made under local anesthesia. The procedure was called **Radial Keratotomy.**

PRK = Photo-Refractive Keratotomy

Using Excimer laser under computer control, a change in the shape of the cornea can be precisely made, by removing sub micron layers from the cornea. The operation is called **PRK = Photo-Refractive Keratotomy** and most of the problems with focusing the image on the retina can be repaired. This operation, which can make eyeglasses obsolete, is very popular among people who care a lot about their appearance, such as actors, politicians, etc.

The entire procedure is new.

At the beginning of 1998, not enough data is available on long term effects, and the procedure is still very expensive (about a thousand US dollars per eye).

2 Lasers in Diagnostic Medicine, and in combination with Drugs:

Diagnostics of cancer cells using Fluorescence, and Photo Dynamic Therapy (PDT)

One of the biggest problems in medicine today is to find a **cure for cancer.**

There are **many treatments for cancer to destroy the cancer cells,** such as:

- Disectomy of the infected organ.
- Radioactive irradiation.
- Heat treatment.

All these treatments improve the chance of cure in some cases, but the "magic" medicine has not yet been found. Since there is no solution yet, the medical professionals are looking for new ways to solve the big problem of cancer.

Photo-Dynamic Therapy (PDT)

In 1972 a new method was developed to identify and destroy cancer cells.

This method is called: **Photo-Dynamic Therapy (PDT).**

It is based on the **use of special drugs** that are injected into the patient body.

These drug accumulates in cancer cells, more than in "normal" cells.

The drugs are sensitive to light at specific wavelengths.

When exposed to these specific wavelengths:

- It can **release chemical substance that kills the cells around it.**
- It can **emit fluorescence light**, so the cancer cells can be identified.

The most well known drug of this family is a derivative of **Hemato-Porfirin (HPD),** and called **Photofrin**.

After the drug is injected into the patient, the **patient must be kept in a dark room** for 24 hours. During this time, the drug is released from healthy cells, and remains at high concentration only in cancer cells.

Than, the patient body is illuminated with specific red laser light at wavelength 630 [nm], which cause the **release of singlet Oxygen**. This oxygen is chemically very active, and destroys the cells around it.

For the last 20 years, these treatments improved the chances of cure in some cases, but the "magic" medicine has not yet been found.

The exact mechanism why the drug remains mainly in cancer cells is not yet understood, and is still under investigation.

After treatment, the patient body remains sensitive to light for a period of about 6 weeks, until all the remains of the drug are released from his body. During this time he is not allowed to be exposed to bright light.

Explanation of the Photofrin drug operation:

After the Photofrin drug absorb light, it is transformed into an **excited state.**

From this excited state there are two possible ways to return to the ground state:

- **Fluorescence** - Where the excited molecule emit photon with in a nanosecond time frame, while returning to the ground state. This phenomenon is used to **identify cancer cells** by searching for the fluorescence.

For diagnostics, the tissue is illuminated by short wavelengths (usually the violet light from a Krypton laser), and the red fluorescence (630-670 [nm]) shows where the cancer cells are.

- **Cross system** - Where the excited molecule is going to a lower energy state without emission of radiation with in microsecond [□sec] time frame. At this excited state, if this molecule meets with Oxygen molecule (O_2), it reacts with it and releases the active singlet Oxygen.

The Future of PDT

The search today is for a **better drug** that will perform the same effect but at a **shorter time scale**, and at **higher efficiency**. Examples are: Chlorides and Ptalo-Cyanines.

Since the irradiation of the infected tissue is done at specific wavelength suitable for the particular drug, **the laser is the preferred choice**. The best laser for this purpose is **the tunable Dye laser.**

The required power depends on the irradiated area, but in general a continuous wave laser at a few Watt power level is used.

The duration of irradiation is a few minutes, so the amount of energy per unit area is measured in tens of Watts.

Another laser that was tried for PDT was the **Gold Vapor laser**, which emits at 628 [nm].

With the rapid developments in **Diode lasers**, they will probably replace other lasers for this purpose as well.

Advantages of PDT:

- The **treatment is harmless**, and can be repeated as needed.
- The **treatment is non-traumatic**, and its influence is for a short term, compared to the radioactive or chemical therapy which lasts weeks.

The wavelengths used for PDT are in the visible spectrum range, and are transmitted well in optical fibers. This property allows irradiation of cancer cells within the body cavities such as digestion system or secretion system.

The entire PDT is still in experimental stage, and is not used as a standard treatment.

3.3 Soft lasers

Most of the medical laser applications were until recently based on the **thermal effects** caused by the electromagnetic radiation which was absorbed in the biological tissue.

In the last few years, some new applications are using low power lasers **with output power less than 1 Watt.**

Some of the effects of these low power levels on the biological tissue is not thermal, and in effect **the mechanism of interaction is not yet clear.**

It is sometimes referred to as **Biostimulation**, which does not explain a lot.

Some of the low power laser applications are:

- **Wound healing** - There are reports in the medical literature that shining a low power visible radiation from Diode laser or He-Ne laser, **at milliwatt power levels** on open wounds, **speed the healing process.** There is not yet any explanation to this phenomena, and there need to be more **controlled research** on the subject.
- **Slow down destruction of injured nerve cells** - so far first experiments have been done only on small animals, on cells from the optic nerve. When a nerve cell is damaged, it is deteriorating rapidly, and die. Shining a low power He-Ne laser radiation on the damage cell seems to slow down this degradation.
- **Reconnection of blood vessels** - Using low power CO_2 laser, surgeons succeeded in connecting blood vessels, without the need to use stitches. The process resembled the metal welding of two tubes.
- **Pain relief** - There are some indications that shining a low power radiation from Diode laser on specific regions which cause pain, or at specific points on the body, can reduce pains.
- **Acupuncture without needles** - Similar to the pain relief, some healers are using milliwatt power from He-Ne or Diode lasers. They treat patients using the same technique which is used in **needle acupuncture** but instead of inserting needles inside the skin, they shine electromagnetic radiation from a laser. **There are no scientific evidences that this treatments are useful**, but at least, there are **no problems of infections** of any kind using the laser compared to needles.

- **Cosmetic applications** - Many cosmetic clinics are using lasers for many kinds of treatments. The best known use of the laser for cosmetics is **peeling the outer layer of the skin (width of 10-30 micron [μm]) by scanning it with a pulsed CO_2 laser.** The layer underneath regenerate a new fresh layer skin. This procedure replace chemical peeling and surgery for skin stretching. Many applications in cosmetics use low power He-Ne or diode lasers, but until scientific evidence will prove their effectiveness, we shall not include them here.

- **Hair Removal** - Using a laser **at specific wavelength**, an area of the skin is illuminated. The laser radiation is absorbed only by the hair (applied only to dark hair on pale skin).

  Some companies are trying to find **techniques which apply to all colors of hair and skin.** An example: they first cover the skin with some black powder, than wiping the power leaving remains of the powder near the roots of the hair. Again, the laser radiation is absorbed only by the black powder parts. These procedures are still in experimental stages. The laser radiation is absorbed by the hair, such that the hair root and nearest cells around it are destroyed. This treatment is used for a **permanent removal of hair (I).**

- **Hair Transplant** - Taking out hair from one place on the body, and "planting" it at another place, by drilling a hole with a laser. This treatment is using hair from the same person, so it is accepted by the surrounding cells, and the **hair continue to grow normally in its new position.** This treatment is **very expensive, and takes a long time**

Biochemistry

Solutions

Definition: Solutions are solutes (substances) dissolved in solvents.

Expressions of concentrations of solutions:

1. **Molar solutions (M):**
   - Definition: These are solutions containing **one gram molecule** (g mol) of the substance **per liter** of the solvent.
   - Example: The molar solution of NaOH = 40 grams/liter.

     Note: The molecular weight of Na= 23, O= 16, H= 1.

2. **Normal solution (N):**
   - Definition: These are solutions containing **one gram equivalent** (g Eq) of the substance **per liter** of the solvent.
   - **One gram equivalent**
     - Is the equivalent weight of the substance expressed in grams.
     - It is obtained by dividing the molecular weight by the number of active radicals, H^+ for acids and OH^- for bases.

3. **Molal solutions:**
   - Definition: These are solutions containing one gram mole of the substance **per 1000 g solvent**.

PH

- **Definition:** PH is defined as the negative logarithm of hydrogen ion concentration.

$$PH = -\log [H^+]$$

Buffers

- **Definition:** buffers are solutions which resist a change in pH following the addition of strong acid or base.
- **Composition:** they are composed of a mixture of either
  1. *A weak acid and its salt with a strong base* e.g carbonic acid + sodium bicarbonate.
  2. *A weak base and its salt with a strong acid* e.g ammonium hydroxide + ammonium chloride.
- **Mechanism of action of buffers:**
  - ✓ On addition of a strong acid e.g HCL to bicarbonate buffer, a neutral salt and weakly dissociated acid are produced which have no effect on pH.

$$HCL + NaHCO_3 \longrightarrow NaCL + H_2CO_3$$

Neutral salt weak acid

  - ✓ On addition of a strong base e.g NaOH to bicarbonate buffer, weakly dissociated base and water are produced.

$$NaOH + H_2CO_3 \longrightarrow NaHCO_3 + H_2O$$

Weakly dissociated base

- **Types of buffers:**

A. *Non-physiologic buffers:*

These are used in biochemical experimentation and include TRIS (PK 8.2) and HEPES (PK7.6).

B. *Physiologic buffers:*

- Any acid or base formed inside the body should be rapidly buffered *since enzymes which control metabolic reactions are very sensitive to change in pH.*

- The **physiologic buffer systems function to keep the pH** within a narrow pH range (7.3 – 7.5).
- Physiologic buffers include:

1) Bicarbonate buffer: $\frac{HCO_3^-}{H_2CO_3}$ (bicarbonate / carbonic acid)

- It is formed of carbonic acid and sodium or potassium bicarbonate.
- It is the **most efficient** buffer in blood.
- The ratio of bicarbonate salt to carbonic acid is **20/1** at pH of 7.4.

2) Phosphate buffer:

- It is formed of $\frac{\text{Acid phosphate}}{\text{Alkaline phosphate}} = \frac{BH_2PO_4}{B_2HPO_4}$
- It is the chief buffer in urine.
- The ratio of base to acid is 4/1.

3) Protein buffer:

- It is formed of $\frac{\text{Proteinic acid}}{\text{Proteinate salt}}$
- The protein buffers include plasma proteins as albumin, globulins and fibrinogen.
- **Note:** in plasma, the base is Na^+ while in RBCs it is K^+.

Vitamins

Definition: Vitamins are organic nutrients which are required in small quantities for normal growth and health.

Characters: 1- Synthesized in body in small amounts

2- Must be supplied in diet

3- Don't enter in the structure of tissues

4- Don't undergo oxidation to give energy

Classification: Vitamins are classified into 2 groups

1. Group I: Includes Vit. A, D, E & K (Fat soluble vitamins)
2. Group II: Includes Vit. C & B-complex (water soluble vitamins)

Comparison between fat & water soluble vitamins:

	Item	Fat soluble vitamins	Water soluble vitamins
1-	Source	Dietary fat	Water of cooked food
2-	Absorption	Needs bile salts	Don't need bile salts
3-	Carrier protein	Need carrier	Need no carrier
4-	Storage	Can be stored in liver	Not stored in the body
5-	Deficiency	Appear later	Appear early
6-	Urine	Can't be excreted	Easily excreted
7-	Overdose	Leads to hypervitaminosis	Hypervitaminosis is rare

A. Fat soluble vitamins

1- Vitamin A (Anti-ophthalmic vitamin)

Functions: vitamin be may be in the form of Retinol, retinoic acid and retinal all have biologic functions;

1) **Retinol:** Involved in control of **gene expression.**

2) **Retinoic acid:** Promotes **growth and differentiation** of tissues.

3) **Retinal:** Has an important role in **vision** as retinal is a component of a visual pigment of the retina called rhodopsin = 11-cis retinal + opsin protein.

4) Vitamin A and carotinoids have **anticancer activity** due to their **antioxidants** effect protecting tissues from **free radicals**.

Deficiency manifestations: These include

1. **Eye** manifestations as **night blindness**:
2. **Reduced mucus** secretions:
3. **Keratinization** of the skin: The skin is rough, scaly & dry.
4. **Delayed growth** of bone & teeth.

2- Vitamin D

Functions:

- The active form of vit D is 1, 25-dihydroxycholecalciferol (1.25 DHCC or calcitriol).
- It increase plasma Ca^{+2} by acting on:

1. **Intestine:** It ↑ intestinal absorption of Ca^{+2} and phosphate.
2. **Kidney:** - It ↑ Ca^{+2} reabsorption from the kidney.
3. **Bone:** It stimulates deposition of Ca^{+2} and phosphate in bone and teeth (help bone mineralization).
4. **Other tissues:** It controls the transfer of divalent cations e.g Ca^{+2} and Mg^{+2} in many tissues as the heart, liver....etc.

Deficiency manifestations: These include

1. **Rickets** in children.
2. **Osteomalacia** in adults.

3- Vitamin E (Anti-sterility vitamin)

Functions: Vitamin E is

1. **Natural antioxidant:** It protects polyunsaturated FAs (PUFAs) from oxidation & peroxide formation.
2. Protects the hepatic stores of vitamin A and D.
3. Act like selenium in helping to remove free radicals e.g superoxide.

Vitamin E Deficiency:

- **Manifestations include:**
  1. **Skeletal muscle breakdown and Hemolytic anemia.**
  2. **Hepatic necrosis** due to intake of PUFAs.
  3. **Sterility** in rats
  4. Prolonged vit. E deficiency may lead to **vit. A deficiency.**
  5. **Neurologic disorders.**

4- Vitamin K (Antihemorrhagic vitamin)

Functions: Vitamin K is required for

1. **Biosynthesis of clotting factors** including prothrombin and factors VII, IX and X.
2. Is an **important antidote** for poisoning by dicumarol like drugs.

Vitamin K Deficiency:

- Deficiency of vit. K in **adults** is rare as it is,
  1- Widely distributed in plant and animal tissues
  2- Produced by intestinal bacteria
- **Manifestations:** include
  - Uncontrolled **bleeding** after a minor trauma, due to hypoprothrombinemia and ↓ plasma level of factors VII, IX & X
- **Diagnosis:** By measurement of prothrombin time (PT).

Enzymes important in clinical diagnosis

❖ There are 2 types of plasma enzymes.

1) **Functional plasma enzymes:**
   - These are enzymes present all times in the circulation of normal individuals and perform a physiologic function in blood.
   - **Examples:** - Lipoprotein lipase, pseudocholinesterase.
   - These enzymes are synthesized in the liver and present in blood in equivalent or higher concentration than in tissues.

2) **Non-functional plasma enzymes:-**
   - These are enzymes that perform no known physiologic function in blood and their levels in the blood are lower than those in tissues.
   - An elevated level of these enzymes in plasma indicates tissue destruction.
   - Measurement of these non-functional plasma enzymes levels can provide valuable diagnostic and prognostic clinical evidence.
   - Non-functional plasma enzymes include;

     ① **Exocrine enzymes:-**

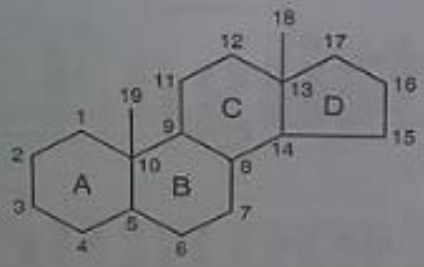
     - These enzymes are present in the exocrine secretions and passively diffuse into the plasmas pancreatic amylase.

     ② **True intracellular enzymes:-**

     - Normally these enzymes are absent from the circulation.

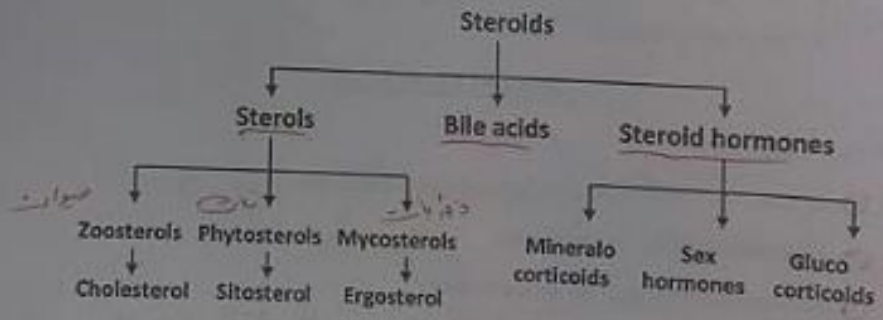
Steroids

- Steroids are derivatives of the Cyclopentanoperhydrophenanthrene nucleus (C17 steroid nucleus).
- The nucleus is formed of 4 rings A, B, C and D
- If the compound contains – OH group it is called sterol.



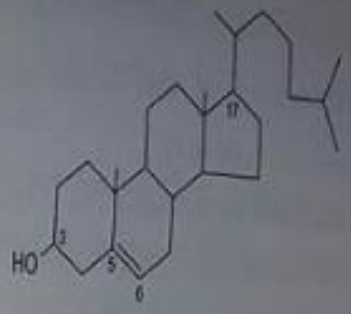
- The steroid nucleus.

➢ **Classification of sterolds:**



Cholesterol

1) Cholesterol has the following characters
   - It is a member of animal sterols.
   - In blood it is found combined with FA forming cholesterol ester



Cholesterol

- Functions of cholesterol:
  1. Major constituent of plasma membrane & plasma lipoproteins.
  2. Synthesis of vitamin D3.
  3. Synthesis of bile acids and steroid hormones

Bile acids

- These are acids present in bile and necessary for digestion and absorption of lipids.

Steroid hormones

- It includes:
  1. Sex hormones: male and female sex hormones.
  2. Glucocorticoids: as cortisone.
  3. Mineralocorticoids: as aldosterone.

Carotinoids

- These are yellow to red pigments which are associated with fat in nature. They are precursors of vitamin A in diet.

Enzymes

Definition: Enzymes are **protein** catalysts that **accelerate** reactions and undergo **physical change** during the reaction but revert to their original state when the reaction is complete.

❖ They increase the rate of chemical reactions by lowering the **free energy barrier** that separates the reactants and products.

Isoenzymes

- **Definition:** - These are physically distinct forms of a given enzyme present in different cell types and catalyze the same reaction.
- These isozymes may differ in their affinity for substrates.
- Example:- Isoenzymes of lactate dehydrogenase enzyme (LDH).
  - LDH enzyme is a tetramer i.e consisting of 4 polypeptide chains of 2 types H and M.
  - Only tetrameric molecule is catalytically active.
  - Synthesis of H and M subunits are controlled by distinct genetic loci in different tissues.
  - Electrophoresis separates LDH isoenzymes into 5 types;
    1- LDH1 HHHH
    2- LDH2 HHHM
    3- LDH3 HHMM
    4- LDH4 HMMM
    5- LDH5 MMMM
  - They are present in different cell types.
  - **Importance of isoenzymes:-** Determination of isoenzymes helps in **diagnosis of diseases** e.g LDH1 and LDH2 are predominant in heart and red cells so, they increase in cases of heart disease

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English Summary

The structure questions

Strategies for the structure questions:

1- **First study the sentence.** Your purpose is to determine what is needed to complete the sentence correctly.
2- **Then study each answer based on how well it completes the sentence.** Eliminate answers that do not complete the sentence correctly.
3- **Do not try to eliminate incorrect answers by looking only at the answers.** Incorrect answers are generally correct by themselves. The incorrect answers are generally incorrect only when used to complete the sentence.
4- **Never leave any answers blank.** Be sure to answer each question even if you are unsure of the correct response.
5- **Do not spend too much time on the structure questions.** Be sure to leave adequate time for the Written Expression questions.

Sentences with multiple clauses

Many sentences in English have more than on clause. (A clause is a group of words containing a subject and a verb.) Whenever you find a sentence on the test with more than one clause, you need to make sure that every subject has a verb and every verb has a subject. Next you need to check that the various clauses in the sentence are correctly joined. There are various ways to join clauses in English test. You should be very familiar with these patterns.

Skill 1: USE COORDINATE CONNECTORS CORRECTLY

When you have two clauses in an English sentence, you must connect the two clauses correctly. One way to connect two clauses is to use *and, but, or, so, or yet* between the clauses.

Tom is singing, and Paul is dancing.
Tom told a joke, so Paul laughed
Tom is tired, yet he is not going to sleep.

In each of these examples, there are two clauses that are correctly joined with a coordinate conjunction and, so, yet, and a comma (,).

1- I know when he will arrive.

NOUN CLAUSE AS OBJECT OF VERBS

2- I am concerned about when he will arrive.

NOUN CLAUSE AS OBJECT OF PREPOSITION

3- When he will arrive is not important.

NOUN CLAUSE AS SUBJECT

In the first example there are two clause, *I know and he will arrive*. These two clauses are joined with the connector *when*. when changes the clause *he will arrive* into a noun clause that functions as the object of the verb *know*.

In the second example the two clauses *I am concerned* and *he will arrive* are also joined by the connector *when*. when changes the clause he will arrive into a noun clause that functions as the object of the preposition about.

The third example is more difficult. In this example there are two clauses, but they are a little harder to recognize. *He will arrive* is one of the clauses, and the connector *When* changes it into a noun clause that functions as the subject of the sentence. The other clause has the noun clause When [illegible] *arrive* as its subject and *is* as its verb.

NOUN CLAUSE CONNRCTORS				
What, when, where, why, how		whatever, whenever	whether, if	that
s v	noun clause as object	s v		
I know	what	you did		
noun clause as subject	s v	v		
what	you did	was wrong		

Skill4: INVERT THE SUBJECT AND VERB WITH QUESTIONWORDS

Subjects and verbs are inverted in a variety of situations in English. Inverted subjects and verbs occur most often in the formation of a question. There is some confusion about when to invert the subject and verb after question words such as *what, when, where, why,* and *how* these words can have two very different functions in a sentence. First, they can introduce a question, and in this case the subject and verb that follow are inverted.

What is the homework?
When can I leave?
Where are you going?

Also, these words can join together ... clauses, and in this case the subject and verb that follow are not inverted.

I do not know what the homework is
When I can leave, I will take the first train.
Do you know where you are going?

In each of these examples there are two clauses joined by a question word. Notice that the subjects and verbs that follow the question words *what*, *when*, and *where* are not inverted in this case.

INVERTED SUBJECTS AND VERBS WITH QUESTION WORDS					
who	what	when	where	why	how
When the question word introduces a question, the subject and verb are inverted.					
	question word	v	s		
	what	are	they?		
When the question word connects two clauses, the subject and verb that follow are not inverted.					
s	v	question wo.		s	v
I	know	what		they	are

Skill 5: INVERT THE SUBJECT AND VERB WITH PLACE EXPRESSIONS

After ideas expressing place, the subject and the verb sometimes invert in English. This can happen with single words expressing place, such as *here, there, or nowhere.*

Here is the book that you lent me.
There are the keys that I thought I lost
Nowhere have I seen such beautiful weather.

In the first example the place word here causes the subject book to come after the verb *is*. In the second example the place word there causes the subject keys to come after the verb *are*. In the last example the place word nowhere causes the subject *I* to come after the verb have.
The subject and verb can also be inverted after prepositional phrases expressing place.

In the closet are the clothes that you want.
Around the corner is Sam's house.
Beyond the mountains lies the town where you will live.

In these examples the prepositional phrase of place causes the subject to come after the verb.

It is important to understand that the subject and verb will invert after place expressions at the the beginning of a sentence only when the place expression is necessary to complete the sentence. Study the following examples:

In the forest are many exotic birds.
In the forest I walked for many hours.

In the first example the subject *birds* and verb *are* are inverted because the place expression *in the forest* is needed to complete the idea *many exotic birds are*..... In the second example the subject *I* and the verb *walked* are not inverted because the idea *I walked for many hours* is complete without the place expression *in the forest*; the place expression is therefore not needed to complete the sentence.

Thanks

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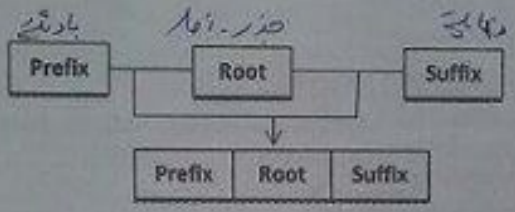
Medical Terminology Summary

MEDICAL WORDS

About 90 % of medical words are of Ancient Greek and Latin origin. It is not difficult to understand them. Medical terms are made up of the following word elements: **prefixes, roots**, and **suffixes**.



Not all terms have all three parts, but let's start by looking at an example that does; periarthritis (per-ee-ar-THRIGH-tis)

Peri / arthr / itis

prefix root suffix

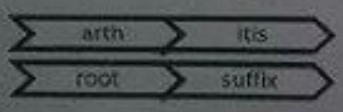
How to Analyze Medical Terms?

When you analyze a term, always start with the suffix. The suffix is -itis, which means "inflammation." Now look at the prefix, peri-. It means "around." By combining these two, you know that the term refers to "inflammation around something." Now look at the middle of the term. It is the root "**arthr**," meaning joint. Putting it all together, we learn that peri**arthr**itis means inflammation around a joint. It is important that you fully understand the proper procedure for analyzing terms.

To analyze a term, always start with the suffix. Then go to the beginning of the word: it will be either a prefix or a root. If there is an additional part in that term, it will be a root.

***TERMS WITH NO PREFIX

Some terms have no prefix. An example is **arthr**itis (ar-**THRIGH**-tis)

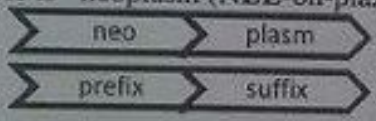


The meaning of the complete medical term, reading from the suffix to the beginning of the word, is "inflammation of a joint."

Root	Meaning	Example(s)
Angi(o), Vas(o)	Blood vessel	Angioplasty, vasoconstriction

***TERMS WITH NO ROOT

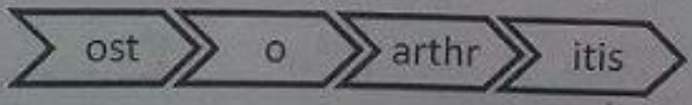
Some terms consist of a prefix and suffix, with no root at all. An example is neoplasm (**NEE**-oh-plazm)

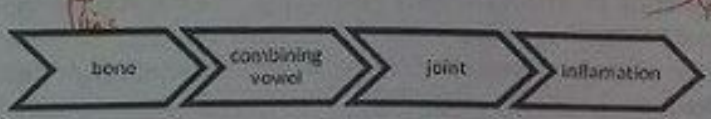


The meaning of the complete term is "new growth."

***TERMS WITH TWO ROOTS

Some terms have two roots followed by a suffix. Examples are:





The meaning of the complete term is inflammation of the bone and joint.

Brachi(o)	Arm	Brachial
Bucc(o)	Cheek	Buccal
Cardi(o)	Heart	Cardiopathy
Carp(o)	Wrist	Carpal tunnel syndrome
Cephal(o)	Head	Cephalic
Colp(o)	Vagina	Colposcopy
Crani(o)	Skull	Craniotomy
Cyst(o)	Bladder	Cystoscopy, cystitis
Cyto	Cell	Cytology, cytomegaly
Dactyl(o)	Finger, toe	Polydactyly
Encephal(o)	Brain	Encephalitis
Enter(o)	Intestine	Enteritis
Gloss(o)	Tongue	Glossitis, glossopharyngeal
Hemo, sanguin(o)	Blood	Hemolytic, serosanguinous
Hyster(o)	Womb, uterus	Hysterectomy
Mast(o), mamm(o)	Breast	Mastitis, mammography
Men(o)	Month, r/t menses	Menopause, menarche, dysmenorrheal
Nephr(o), Ren(o)	Kidney	Nephrectomy, renal
Oophor(o)	Ovary	Oopherectomy
Ophthalm, Ocul(o)	Eye	Ophthalmoscope, ocular
Ot(o), Auri, Aud	Ear	Otitis, auricle, audiometer
Phleb(o), Ven(o)	Vein	Phlebitis, venous
Pod	Foot	Podiatrist
Rhin(o)	Nose	Rhinoplasty, rhinorrhea
Salping(o)	Fallopian tube	Salpingectomy, salpingitis
Thorac(o)	Chest	Thoracotomy, thoracic
Thromb(o)	Clot	Thrombosis, thrombolytic

II. Prefixes :Colors

Prefix	Meaning	Example(s)
Erythr(o)	Red	Erythema, erythrocyte
Leuk(o), leuc(o)	White	Leukocytes, leukemia
Cyan(o)	Blue	Cyanosis
Melan(o)	Black	Melanin
Cirrh(o)	Yellow	Cirrhosis

Prefix	Meaning	Example(s)
Ankyl(o)	Stiff, fixed, crooked	Ankylosis
Sten(o), Stric	Narrow	Stenosis, stricture
Ortho	Straight position	Orthopnea, orthopedic
Kypho	Bent, crooked	Kyphoscoliosis, kyphosis
Pseudo	False	Pseudostrabismus, pseudoaneurysm

Descriptions

Prefix	Meaning	Example(s)

ost
Root
bone

o
Compounding word
(مركب)

arthr
Root
Joint

itis
suffix
inflammation

Measurements

Prefix	Meaning	Example(s)
Macro	Large	Macrophage, macrocephaly
Micro	Small	Microscopic, microorganism
Poly, Hyper, Multi	Many, much	Polydypsia, hyperthyroidism, multiple
Brady	Slow	Bradypnea
Tachy	Fast	Tachycardia
Oligo, Hypo	Few	Oliguria, hypothermia
Iso	Equal	Isometric, isotonic
Diplo, Ambi	Both, double	Diplopia, ambidextrous
Hemi	Half	Hemiplegia, hemisphere
Pan	All	Pansystolic, pancytopenia

Positions

Pro, Ante, Pre	Before	Prodromal, antepartum, precapillary
Post	After	Postnatal, posterior
Super, supra	Above	Superior, supraclavicular
Sub	Below	Submandibular, subcutaneous
Dors(o)	Back	Dorsoflexion, dorsal
Retro	Backwards	Retrograde, retrosternal
Para	Beside	Paramedic, paranasal
Re	Again	Rehydrate, recuperate
Later(o)	Side	Lateral
Medi(o)	Middle	Medial, mediastinum
Schizo	Split	Schizophrenia
Inter	Between	Intercostals, interdigital
Heter(o)	Different	Heterogeneous
Hom(o)	Same	Homozygous
Ad(o)	Towards	Adduction, adhesion, adrenal
Ab(o)	Away from	Abduction, abnormal
Anti, Contra	Against	Antigen, contraception
Endo, In, Intra	In, within, inside	Endocarditis, inhale, intrapartum
Ex(o), Ec(to)	Out	Exhale, ectopic
Epi	Upon, above	Epidermis, epigastric, epiglottis
Dia, Trans	Through	Diameter, transfusion
Peri, Circum	Around	Perinatal, circumcision
Sinister(a)	Left	OS (oculus sinister – left eye)
Dextr(o)	Right	OD (oculus dexter – right eye)

The Body

Prefix Root	Meaning	Example(s)
Aden(o)	Gland	Adenoma, adenoids
Arthr(o)	Joint	Arthritis, arthroscopy
Cervic(o)	Neck	Cervical, cervicitis
Costo	Rib	Costochondritis, costovertebral
Cyto	Cell	Cytology, cytomegaly
Derm	Skin	Dermatitis, dermatological
Gastr(o)	Stomach	Gastritis, gastrointestinal
Glosso	Tongue	Glossopharyngeal, glossitis
Heme	Blood	Hematuria, hematemesis, hemangioma
Hepat(o)	Liver	Hepatitis, hepatocellular
Lingu	Tongue	Lingual, linguistic
Litho	Stone	Lithotomy, lithotripsy
My	Muscle	Myoma, myalgia
Myo, myel	Marrow	Myelitis

Roots

Neuro	Nerve	Neuromyalgia
Oto	Ear	Otitis, otolaryngology
Opti, Ocu	Eye	Optician, ocular
Osteo	Bone	Osteoarthritis, osteopenia
Pneum(o), Pulm	Lung	Pneumothorax, pulmonary
Psycho	Mind	Psychology, psychopath, psychosomatic
Rhino	Nose	Rhinorrhea, rhinitis
Thor(a)	Chest	Thoracic, thoracentesis
Vasc	Vessel	Vasculitis

Prefix	**Meaning**	**Example(s)**
A(n)	Without	Anemia, avascular
Auto	Self	Autoimmune
Dys	Difficult, painful	Dyspnea, dysuria
Gravida	Pregnant, heavy	Gravidity
Neo	New	Neonatal, neoplasm
Anti	Against	Antidote
Contra-	Against	Contraindication
De-	Removal	Detoxify
Dis-	Removal	Disinfectant
In- Im- Un-	Not	Incontinence Immature Unstable

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Medical Statistics Summary

Medical Statistics

Medical statistics is the science of collecting, presenting, analyzing and interpreting data in medical practice, and using them to estimate the magnitude of associations and test hypotheses.

DATA

Definition:

Set of values of one or more variables recorded in one or more observational units or numerical description of quantitative or qualitative aspects of things.

Types of data

1-**Constant:** Observation which does not varies from one person to another, E.g. number of chromosomes in a gene.

2- **Variables**: Observation which vary from one person to another.

Variables

- ***Quantitative variables:*** are expressed in numbers.
- ***Qualitative variables***

Also known as categorical variables, qualitative variables are variables with no natural sense of ordering. They are therefore measured on a nominal scale. For instance, hair color (Black, Brown, Gray, Red, and Yellow) is a qualitative variable

Methods of data collection:

1. **Historical records**: e.g.
   a. Censuses
   b. Vital statistics records
   c. Epidemiological records
   d. Scientific journals and textbooks

2. **Experimental.** تجريبي

3. **Conducting surveys:** الدراسات - الاستطلاعات

a. Comprehensive surveys مسح شامل

b. Sample surveys (مبنية على عينات) عينية وأخذ عينات

Sampling Techniques

Probability or Random samples

Characteristics:

1. The probability of selection of an individual from the population can be determined. احتمالية اختيار الفرد من العينة يمكن أن يحدد
2. The standard error of the sample result can be computed. الخطأ المعياري (يمكن حسابه)
3. Generalization of the sample results over the total population can be made. تعميم نتائج العينة على المجتمع الكلي

Types of probability samples: أنواع

1. Simple random sample بسيط
2. Systematic random sample منتظم
3. Stratified random sample طبقي
4. Multi-stage random sample متعدد المراحل
5. Cluster sample عنقودي

Methods of presentation of data طرق تمثيل البيانات

1. Tabular presentation التمثيل الجدولي

- Simple frequency distribution table توزيع تكراري بسيط
- Relative frequency distribution table توزيع تكراري نسبي (توزيع وحدات نسبية)
- Cumulative relative frequency distribution table جدول توزيع الوحدات بالتكرار النسبي المتجمع
- Complex table معقد
- (R) (C) complex table صف وعمود معقد
- [2X2] contingency table

2. Graphical presentation الرسومات البيانية

1. **Bar chart**
   - Simple bar
   - Complex bar
   - Component bat
2. **Histogram**
3. **Pie chart**
4. **Time graph**

3. Mathematical presentation

Types of mathematical calculation of data

A. Measures of central tendencies, location or average:-

[One figure to represent a group of figures]

1. Mean (X)
2. Median
3. Mode (Mo)
4. Mid-range

B. Measures of dispersion, scatter or deviation: -

1. Range (R)
2. Standard deviation (SD)

A) Measures of central tendencies, location or average

I. Mean:

$\frac{\sum(X)}{n}$

a. Arithemetic mean: X:

Calculation of the mean

Example: Compute the mean from the following observations: 1, 2, 3, 4, 5 and 6

The mean = $(\sum Xi)/n$ = summation of observations/ number of observations

Where $\sum$ = sum of: - Xi = individual observations

n = number of observations

II. Median:

Calculation of median

الوسط الحسابي

Median = $\frac{n+1}{2}$

Example: The weight in kg of 7 individuals was 21, 22, 45, 30, 25, 21 and 32. Compute the median.

The answer:

→ Firstly, we should rank these observations in an ascending or a descending manner:

ترتيب 21 - 21 - 22 - 25 - 30 - 45 - 32 - 95

21, 21, 22, 25, 30, 32 and 45.

→ The location is determined as follows: $\frac{n+1}{2} = \frac{8}{2} = 4$

In this example, the median will be at 4th observation =25

N.B In even observations, the median is equal to the average of the middle 2 observations. ***(Examples in practical book)***

III. The mode: المنوال

The most frequent observation

- Compute the mode from the following observations: 2, 3, 4, 4, and 6.
- The mode is the most frequent observation = 4
- Sometimes, no mode is present; two modes may be present (bimodal), or three modes (tri-modal).

المنوال - أحادي - أضعافي

IV. The mid-range: منتصف المدى

$$\text{The mid-range} = \frac{\text{The smallest observation} + \text{the largest observation}}{2}$$

المتوسط الحسابي

B. Measures of dispersion, scatter or deviation

It gives an idea about the variability and deviation of observations around the mean.

I. Range: The range = the difference between the highest and lowest scores

Calculation of the range:

Example (1), if the weights of 7 pregnant women were 40, 41, 42, 43, 44, 47, and 72 kg, the range would be 72 - 40 = 32 kg.

2. Standard deviation: (SD)

Calculation of SD:

- Calculate SD from the following: 1, 2, 3

Another answer:

1. Compute the deviation of each figure from the mean.
2. Square each deviation.
3. Divide the sum by the number of observations -1 i.e (n-1).
4. Find the square root of the step [3], this is the SD.

Vital Statistics

Fertility rates

1- Crude Birth Rate (CBR):

It is defined as the number of live births occurring during a calendar period per 1000 of the average population during the same period: i.e.

$$\frac{\text{Total number of live births in a certain area and year x}}{\text{Estimated mid-year population in the same area any year}} \times 1000$$

2) General Fertility Rate (GFR):

$$GFR = \frac{\text{No. of live births in certain area and year}}{\text{No. of females in the child bearing age in the same area and year}} \times 1000$$

معدل الخصوبة الزوجي

(3) Fecundity Rate (Marital Fertility Rate):

- It is calculated as:

$$\frac{\text{No. of live births in a certain area and year}}{\text{No. of married women (15-49 years) in the same area and year}} \times 1000$$

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(4) Age specific fertility rate:

$$\frac{\text{No. of births born for females in a specific age group}}{\text{No. of females in the same age group}} \times 1000$$

مجموع معدلات الخصوبة لمختلف الأعمار في سن الإنجاب

(5) Total Fertility Rate:

- It is the summation of age specific fertility rates. It represents the number of births that would be born to women throughout their reproductive period.

Total fertility rate (R) (born per woman) 2.87 2014 .

2. Mortality rates (Death rates)

معدل الوفيات

3. Morbidity statistics

معدل الحالات المرضية

- Prevalence rate معدل انتشار المرض
- Incidence rate معدل الإصابة

FACULTY OF APPLIED
MEDICAL SCIENCES
كلية العلوم الطبية التطبيقية

Biotechnology Summary

Biotechnology

Contrary to its name, biotechnology is not a single technology. Rather it is a group of technologies that share two (common) characteristics -- working with living cells and their molecules and having a wide range of practice uses that can improve our lives. Biotechnology can be broadly defined as "using organisms or their products for commercial purposes." As such, (traditional) biotechnology has been practices since the beginning of records history. (It has been used to:) bake bread, brew alcoholic beverages, and breed food crops or domestic animals. But recent developments in molecular biology have given biotechnology new meaning, new prominence, and new potential. It is (modern) biotechnology that has captured the attention of the public. Modern biotechnology can have a dramatic effect on the world economy and society. One example of modern biotechnology is genetic engineering. Genetic engineering is the process of transferring individual genes between organisms or modifying the genes in an organism to remove or add a desired trait or characteristic. Examples of genetic engineering are described later in this document. Through genetic engineering, genetically modified crops or organisms are formed.

Modern biotechnology

All organisms are made up of cells that are programmed by the same basic genetic material, called DNA (deoxyribonucleic acid). Each unit of DNA is made up of a combination of the following nucleotides adenine (A), guanine (G), thymine (T), and cytosine (D) -- as well as a sugar and a phosphate. These nucleotides pair up into strands that twist together into a spiral structure call a "double helix." This double helix is DNA. Segments of the DNA tell individual cells how to produce specific proteins. These segments are genes. It is the presence or absence of the specific protein that gives an organism a trait or characteristic. More than 10,000 different genes are found in most plant and animal species. This total set of genes for an organism is organized into chromosomes within the cell nucleus.

Industrial biotechnology

Industrial biotechnology applies the techniques of modern molecular biology to improve the efficiency and reduce the environmental impacts of industrial processes like textile, paper and pulp, and chemical manufacturing. For example, industrial biotechnology companies develop biocatalysts, such as enzymes, to synthesize chemicals. Enzymes are proteins produced by all organisms. Using biotechnology, the desired enzyme can be manufactured in commercial quantities. Commodity chemicals (e.g., polymer-grade acrylamide) and specialty chemicals can be produced using biotech applications. Traditional chemical synthesis involves large amounts of energy and often-undesirable products, such as HCl. Using biocatalysts, the same chemicals can be produced more economically and more environmentally friendly. An example would be the substitution of protease in detergents for other cleaning compounds. Detergent proteases, which remove protein impurities, are essential components of modern detergents. They are used to break down protein, starch, and fatty acids present on items being washed. Protease production results in a biomass that in turn yields a useful byproduct- an organic fertilizer. Biotechnology is also used in the textile industry for the finishing of fabrics and garments.

Biotechnology also produces biotech-derived cotton that is warmer, stronger, has improved dye uptake and retention, enhanced absorbency, and wrinkle- and shrink-resistance. Some agricultural crops, such as corn, can be used in place of petroleum to produce chemicals. The crop's sugar can be fermented to acid, which can be then used as an intermediate to produce other chemical feedstocks for various products. It has been projected that 30% of the world's chemical and fuel needs could be supplied by such renewable resources in the first half of the next century. It has been demonstrated, at test scale, that biopulping reduces the electrical energy required for wood pulping process by 30%.

Waste water treatment

It was now a well- established fact that human health and well-being of communities was inextricably linked to the health and integrity of their ecosystems. In its 1997 report on the State of Health and the Environment, WHO concluded that the poor quality of the environment (and of ecosystems) was directly responsible for 25 % of all diseases that could be classed as preventable (e.g., acute respiratory infections, malaria, diarrhea, hepatitis was and occupational illnesses). Water contamination by point sources of pollution from domestic discharge occurs in many parts of Egypt, particularly in the rural villages. Water pollution, if allowed to grow uncontrolled, was likely to cause substantial economic and health ramifications to the country. If we evaluate the current urban water management practices in Egypt from a cleaner production point of view, the urgency to re-think our current practices in the light of sustainability becomes evident. A cleaner production check results in two main priority areas for action; the pollution prevention and resources recovery & reuse. Currently available infrastructure for sewerage, waste water treatment schemes at the 'end of the pipe' should be aimed at maximizing energy, water and nutrient recovery.

Environmental biotechnology

Environmental biotechnology is the used in waste treatment and pollution prevention. Environmental biotechnology can more efficiently clean up many wastes than conventional methods and greatly reduce our dependence on methods for land-based disposal. Every organism ingests nutrients to live and produces by-products as a result. Different organisms need different types of nutrients. Some bacteria thrive on the chemical components of waste products. Environmental engineers use bioremediation, the broadest application of environmental biotechnology, in two basic ways. They introduce nutrients to stimulate the activity of bacteria already present in the soil at a waste site, or add new bacteria to the soil. The 5 bacteria digest the waste at the site and turn it into harmless byproducts. After the bacteria consume the waste materials, they die off or return to their normal population levels in the environment. Bioremediation, is an area of increasing interest. Through application of biotechnical methods, enzyme bioreactors are being developed that will pretreat some industrial waste and food waste components and allow their removal through the sewage system rather than through solid waste disposal mechanisms. Waste can also be converted to biofuel to run generators. Microbes can be induced to produce enzymes needed to convert plant and vegetable materials into

building blocks for biodegradable plastics. In some cases, the byproducts of the pollution-fighting microorganisms are themselves useful. For example, methane can be derived from a form of bacteria that degrades sulfur liquor, a waste product of paper manufacturing. This methane can then be used as a fuel or in other industrial processes.

Basic

Medical

Biology

CELL MEMBRANE (Plasmalemma)

Molecular structure of the cell membrane:

→ ***1-lipid bilayer*** is formed of Phospholipids and Cholesterol molecules between phospholipids. Each phospholipid molecule is composed of:

ⓐ ***a polar:*** hydrophilic head located at the surface of the membrane

ⓑ ***two long non polar:**** hydrophobic tails projecting into the center of the plasmalemma

→ ***2-The protein component:***

a-Intrinsic (Integral) protein:

It is formed of ***globular molecules extending*** from one side of the membrane to the other being ***embedded*** in the lipid bilayer and referred to as ***transmembrane proteins.***

They form ion channels and carrier proteins that facilitate the passage of specific ions and molecules across the cell membrane.

b-Extrinsic (Peripheral) protein:

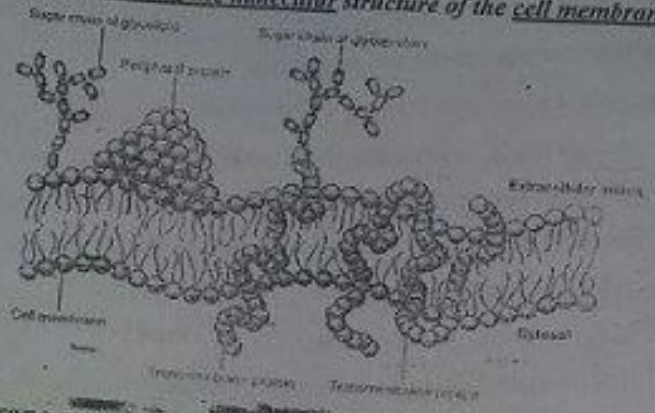
It is less firmly attached to the outer and inner aspects of the membrane and is held there by weak electrostatic forces.

The fluid mosaic model for cell membrane structure:

The ***mosaic disposition*** of membrane ***proteins*** and the fluid nature of the ***lipid bilayer*** makes the integral proteins float like ice bergs in the sea of phospholipids. This constitutes the basis of the ***fluid mosaic model*** for membrane structure.

The lipid Nature of cell membrane makes Proteins appear like ice bergs.

Diagram showing the molecular structure of the cell membrane.



Functional membrane proteins:

1- Pump protein: for active transport across the cell membrane.
2- Channel protein: allows passage of small ions and molecules across the cell membrane. It is present in nerve cells and gap junctions.
3- Receptor protein: recognizes and binds substances to outer surface of cell membrane.
4- Enzyme protein: as ATP-ase.
5- Structural protein: as which is present in tight junctions.
6- Linker protein: anchors the intracellular cytoskeleton to the extra- cellular matrix as integrins.

CELL COAT (GLYCOCALYX):

The *carbohydrate* component of cell membrane attached to transmembrane proteins and phospholipid molecules of the outer leaflet constitutes a fuzzy coat, referred to as the ***cell coat*** or ***glycocalyx.***

It stains with *Alcian blue.*

Functions of the glycocalyx are:

1- Protection of the cell from interaction with inappropriate proteins and from chemical or physical injury.
2- Cell to cell recognition and adhesion.
3- formation of basement membrane

Asymmetry of cell membrane:

The inner and outer halves of the cell membrane differ showing *asymmetry* due to:

a- *Cell coat* is present on the outer surface only.

b-Different lipid composition (chemical variation): the cholesterol and aminophospholipids mostly in the inner half of the membrane.

c-Cell receptors on the outer surface of the membrane.

They are molecules which react with specific substances as viruses or bacteria.

d-Differences in thickness between the two halves.

Functions of the cell membrane:

1- Maintains structural integrity of the cell.

2- Controls movements of substances in and out of the cell through: a-microtransfer b- macrotransfer c- sodium potassium pump.

3- Regulates cell to cell interactions.

4- Recognition (via receptors) of antigens, foreign cells.

5- Acts as an interface between the cytoplasm and the external media.

6- Transducing extracellular physical or -chemical signals into intracellular events.

7- Participation in formation of myelin sheath in nervous tissue.

MEMBRANEOUS ORGANELLES

Membraneous organelles are consists of:

1- Endoplasmic Reticulum

It is the largest membranous system of the cell.

Types: 1- Rough endoplasmic reticulum (RER). 2- Smooth endoplasmic reticulum (SER).

Origin of ER: RER arises from *nuclear membrane*.

SER arises from RER by *loss* of its ribosomes.

A) Rough endoplasmic reticulum (RER):

- **LM:** It appears as basophilia of the cytoplasm.
- **EM:** It consists of sac-like and parallel stacks of flattened cisterns& tubules that are sometimes continuous with the outer membrane of the nuclear envelope.
- Presence of ribosomes attached to the cytosolic surface of its membrane.
- Present in all cells but well developed in cells, which *synthesize proteins* as e.g. glandular secretory cells and fibroblasts.
- **Function:**

1. Protein synthesis: which is formed on the ribosomes.
2. Segregation of special types of proteins (mostly enzymes) inside the cisterns.
3. Protection of cytoplasm: by segregation of proteolytic enzymes inside cisterns.
4. Ascorbic acid (vitamin C) synthesis.

B) Smooth endoplasmic reticulum (SER):

- **LM:** It appears as acidophilia of cytoplasm.
- **EM:** it consists of anastomosing tubules and flattened vesicles.
- Absence of ribosomes from its cytosolic surface.

- Well developed in cells that synthesize steroids, cholesterol and triglycerides and cells that function in detoxification of toxic materials.

- **Functions:**

1. Lipid synthesis: e.g. lipoproteins in liver cells, steroid hormones in adrenal cortex
2. Phospholipids synthesis.
3. Glycogen metabolism.
4. Calcium concentration: in muscular tissue for contraction.
5. Neutralization and detoxification: in liver cells where hormones and drugs are broken down.
6. Hydrochloric acid (HCl) synthesis:
7. concentration of chlorine ions.
8. Pigment synthesis: in retina.
9. Sharing in formation of blood platelets.
10. Formation of lysosomes.

2-Golgi Apparatus

- **Site**: its position depends on cell activity it is present at one side of the nucleus (basal or apical) as in glandular cells or surrounding the nucleus as in nerve cells.
- **LM**: in living cells: by phase contrast microscope or after vital staining.

After *silver* staining or *osmic acid* fixation it appears as fibrillar or granular network (*positive* Golgi image).

In H&E stained sections, it appears as lightly stained areas (*negative* Golgi image).

- **EM:** It appears to be formed of three components:

A) Flattened vesicles or saccules:

These are 4-10 parallel elongated smooth surfaced double-walled membranous sacs or cistemae forming stacks.

The lumens of these cistemae are narrow & expanded at their ends.

The cistemae have a convex surface and a concave surface.

1-The convex surface:

It is called *cis-face* or *immature face* of the organelle.

The secretory protein is transported from the endoplasmic reticulum to this convex surface.

2-The concave surface:

It is called trans-face or mature face. The secretory vesicles are released from it. The transport of material from the cis to the trans-face of the organelle is believed to depend on vesicles *budding off* from one cistema and fusing with the next in the stack.

B) Microvesicles or transfer vesicles:

These are smooth-surfaced *small* spherical vesicles.

Arising by budding from the RER, migrating through the cytoplasm, fuse with the immature face of the Golgi where they discharge their contents thus causing expansion of the saccules.

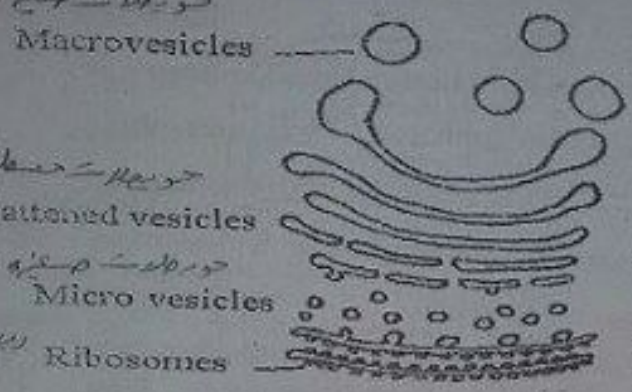
C) Macrovesicles or secretory vesicles:

These are smooth-surfaced *large* spherical vesicles.

Arising by budding from the periphery of the saccules of the mature face. They contain formed substances.

They either migrate to fuse with the cell membrane and discharge their contents through it to the outside as *secretory granules* or remain in the cytoplasm as *lysosomes*.

They are enveloped by a membrane. Their membranes present a high degree of selectivity in fusion with the plasma membrane e.g. in pancreatic cells, secretory vesicles fuse only with the apical membrane.



Functions:

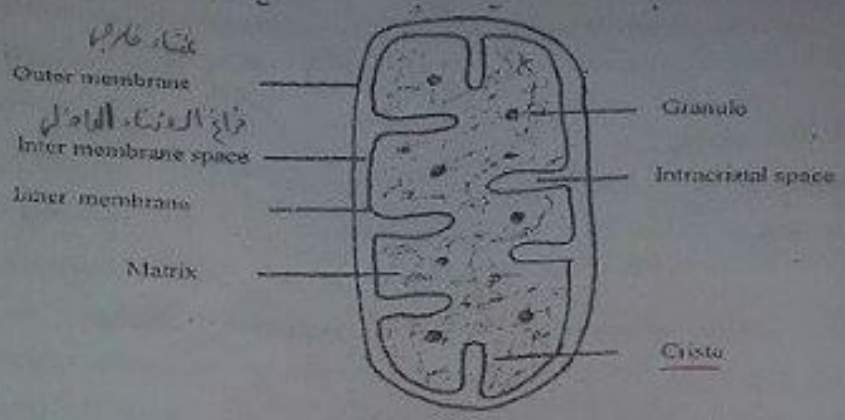
1. processing of secretory products e.g. insulin (by converting the inactive proinsulin into active insulin).
2. Addition of carbohydrate fractions to proteins coming from RER to form glycoproteins.
3. Involved in the production of complex carbohydrates, mucoproteins and lipoproteins.
4. Formation and maintenance of membranes and cell coat.
5. Concentration and packaging of secretory products.
6. Shares with RER in production of *lysosomes*

3- Mitochondria

Site: distributed all over the cytoplasm in nearly all cells

LM

- In living cells: As cultured cells under the phase contrast microscope and dark field microscope.
- After supravital staining as Janus green stain .It can move, change shape and size, divide and fuse.
- After iron haematoxylin stain, they appear as granules, rods or filaments of
- variable number, length and size depending on cell act



EM: Each mitochondrion is formed of:

1-The outer membrane:

It is permeable to water and ions.

2-The inner membrane: formed of

a-Folds called cristae their shape may be

1-transverse plates in the most cells.

2- *tubular* in steroid secreting cells.

b-Elementary particles associated with the cristae.

These particles appear as projections regularly spaced and attached to the inner membrane by stalks.

3-intermembrane spac:

The narrow space between the inner and outer membranes.

4-The matrix space

The large space enclosed by the inner membrane.

The matrix space is filled with:

1-dense fluid composed of protein as enzymes responsible for *oxidative phosphorylation* and electron transport systems and enzymes for *Krebs cycle*.

2-mitochondrial ribosome, tRNA, rRNA

3-double-stranded mitochondrial DNA

- ***Functions:***

1- Cell respiration: being the site of Krebs cycle and oxidative phosphorylation thus providing the ATP which is an energy rich compound.

2- Lipid metabolism (synthesis and breakdown).

3- Concentration of certain ions as e.g. Ca ions, thus controlling its general level within the cytoplasm.

4- Initiation of apoptosis (programmed cell death).

5- Heat production to maintain normal body temperature.

4-Lysosomes

Lysosomes are membranous vesicles containing *hydrolytic enzymes* which are active at an acid pH (5.0) such as proteases, lipases and nucleases among others which are at least 40 types of acid hydrolyses.

present in all cells specially those have phagocytic activity. number, size and shape are variable.

LM: identified by special histochemical methods for their enzymes.

EM: They appear as homogenous membrane bound vesicles According to their content and appearance classified into:

1- **Prelysosomes:** They contain *substrates* and may be:

a-Heterophagosomes: containing exogenous substrates entering into the cell by phagocytosis or pinocytosis and enclosed within a membrane.

b-Autophagosomes: containing endogenous substrates derived from cytoplasmic organoids (excess old organelles such as mitochondria or endoplasmic reticulum).

2- **Primary lysosomes:**

Are freshly formed lysosomes contain *hydrolytic enzymes* only.

They are small, spherical and their contents are *homogenous*.

Secondary lysosomes:

Are formed by fusion of the primary lysosomes with the prelysosomes and they may be:

a- Heterolysosomes: formed by fusion of primary lsosomes with heterophagosomes.

b- Autolysosomes: formed by fusion of primary lysosomes with autophagosomes.

c- Multivesicular bodies: formed by the fusion of primary lysosomes with pinocytotic vesicles.

Postlysosomes (residual bodies):

The hydrolytic enzymes digest most of the contents of the phagosome especially the protein and carbohydrate components. Lipids are more resistant to complete digestion and they remain forming residual body.

They have *no enzymatic activity* and are common to both hetero and autophagy.

Functions:

1- *Defensive* function against bacteria, viruses etc.

2- intracellular digestion

3- Play an important role in *metamorphosis*, embryonic *morphogenesis* and\ elimination of worn out organelles.

4- *Remodeling of tissues* e.g. bone.

5-Peroxisomes (Microbodies)

These are small (0.2 to 1.0 µm in diameter) spherical to ovoid membrane-bound organelles. They contain *oxidative enzymes*, especially urate **oxidase**, catalase and D-amino acid oxidase.

Site: present in almost all animal cells especially hepatic cells.

LM: They appear after special cytochemical methods for their enzymes as **e.g. DAB** (3, 3 diaminoazobenzidine) reaction for the catalase.

EM: They appear as spherical microbodies bound by a single membrane and with a finely granular matrix. In some animals they may have cores of urate oxidase which show crystal-like arrangement.

Functions:

1-Degradation of purines by oxidases yielding hydrogen peroxide (H202) then destroying it by the catalase thus protecting the cell against it.

2-Catabolism of long-chained fatty acids forming *acetyl CoA & H202.* Acetyl CoA is used by the cell for its own metabolic needs. Hydrogen peroxide detoxifies various noxious agents and kills microorganisms. Excess H_2O_2 is destroyed by catalase.

6-Endosomes

They are small membranous organelles.

- They have proton (H^+) pumps to acidify their contents.
- Types: early and late endosomes.

1-Early endosomes: present near the cell membrane with pH 6.

2-Late endosomes: present deeper in the cytoplasm with pH 5.5.

- ***Function:*** They share in transport of endocytosed material and biogenesis of lysosomes.

So membranous organelles can be listed as follow:

1-Cell Membrane
2-Endoplasmic Reticulum
3-Golgi Apparatus
4- Mitochondria
5- Lysosomes
6-Perixsome
7-Endosome

NON-MEMBRANOUS ORGANELLES

1-Ribosomes

Definition: Ribosomes are granule-like structures found in both prokaryotic and eukaryotic cells.

L/M:

- They are found distributed all over the cytoplasm.
- It consists of two subunits, one large and one small. Particles consisted of proteins and ribosomal RNA (rRNA).

Types of ribosomes:

1- Free ribosomes: In eukaryotic cell ribosomes occur freely in the cytoplasm.

2- Attached ribosomes: to the surface of endoplasmic reticulum (RER).

3- Polysomes: It may occur in groups of 10 free ribosomes attached to mRNA and called polysomes.

Site: scattered in the cytoplasm or in the matrix of organelles like mitochondria and chloroplasts. It is also found attached to the nuclear membrane and inside the nucleolus.

Number of ribosomes: variable depending on cell function. For example Liver cells contain many more ribosomes to synthesize liver proteins than fat cells that synthesize triglycerides.

Function of ribosomes:

1-Free ribosomes in cytosol synthesize proteins that function within cytosol.

2-Attached ribosomes synthesize membrane protein, organelle proteins or secretory proteins.

2-Cytoskeleton

Definition: Is a complex protein network that acts as cellular "bone and muscle".

Composed of microtubules, microfilaments and intermediate filaments.

Microtubules

- Are straight, hollow cylinders, have a diameter of about 25 nm and are variable in length.

- Are built by the assembly of dimers of **alpha tubulin** and **beta tubulin**.
- The wall of a microtubule is composed of 13 parallel filaments called protofilaments.
- Are found in both animal and plant cells

Function of microtubules:

1- support the cell and maintain its shape

2-serve as track along which organelle can move inside cytoplasm.

3- responsible for separation of chromosome during cell division

4- component of centrosome, centrioles, cilia and flagella.

Microfilaments

- Microfilaments are solid, unbranched rod-like fibrils of varying length.
- They are most predominant in the muscle cells, where they are called as myofilaments.
- They are mainly composed of a globular protein called actin.

Function of microfilaments:

1-maintanance of cell shape

2-muscle contraction

3-cell motility as in pseudopodia

4-cell division (cleavage furrow formation)

Intermediate filament

Cytoplasmic ropelike fibers with average 10 nm in diameter (thus are "intermediate" in s
between actin filaments (8 nm) and microtubules (25 nm).

There are several types of intermediate filament as:

1-Keratins are found in epithelial cells and form hair and nails

2-Nuclear lamins form a meshwork that stabilizes the inner membrane of the nuclear envelope

3-Neurofilaments strengthen the long axons of neurons;

4-Vimentins provide mechanical strength to muscle

filaments.

ofilaments.

diate" in size

ar envelope

3-Centrosomes and Centrioles

Centrosomes (microtubule-organizing center) = a region near the nucleus from whic microtubules originates.

Centrioles:

Each centrosome contains a pair of centrioles.

L/M: appears as two small dots near the upper pole of the nucleus.

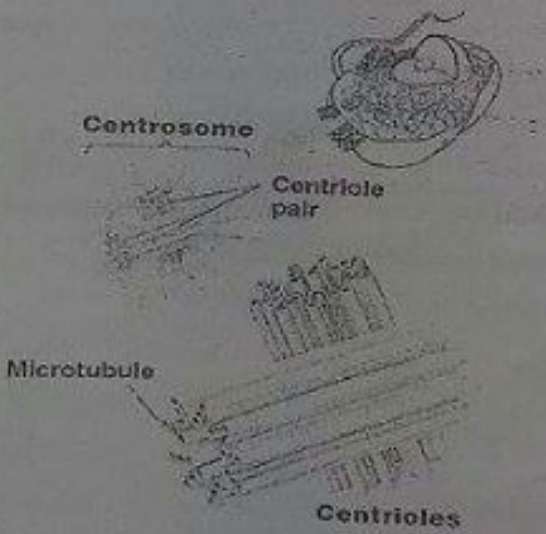
E/M:

- The centrioles appear as two short, hollow, cylinders usually lying at right angles to each other.
- Each centriole is made up of nine microtubule triplets, which lie evenly spaced in a ring. There are no microtubules in the center (9+0 arrangement).
- Centrioles replicate before cell division.

Function of centrioles:

1- Centrioles are involved in organizing the spindle fibres during cell division in animal cells.

2- They provide basal bodies from which arise cilia and flagella.



4-Cilia

L/M: Are long hair-like extensions of cell membrane.

E/M: Cilia is made of microtubules core sheathed in an extension of plasma membrane "9+2" arrangement of microtubules (9 doublets + 2 singlet).

Is anchored in the cell by a basal body, whose structure is identical to a centriole.

Types of cilia:

1- **'Motile' (or moving)** cilia are found in the lungs, respiratory tract and middle ear. These cilia have a rhythmic waving or beating motion. They work to keep the airways clear of mucus and dirt, allowing us to breathe easily and without irritation.

2- **'Non-motile or 'primary'** cilia act as a sensory antenna for the cell, receiving signals from other cells or fluids nearby.

- In the kidney, for example, cilia bend with urine flow and send a signal to alert the cells that there is a flow of urine.
- In the eye, non-motile cilia are found inside the light-sensitive cells (photoreceptors) of the retina. These cilia act like microscopic train-tracks, and allow the transport of vital molecules from one end of the photoreceptor to the other.

Function of cilia:

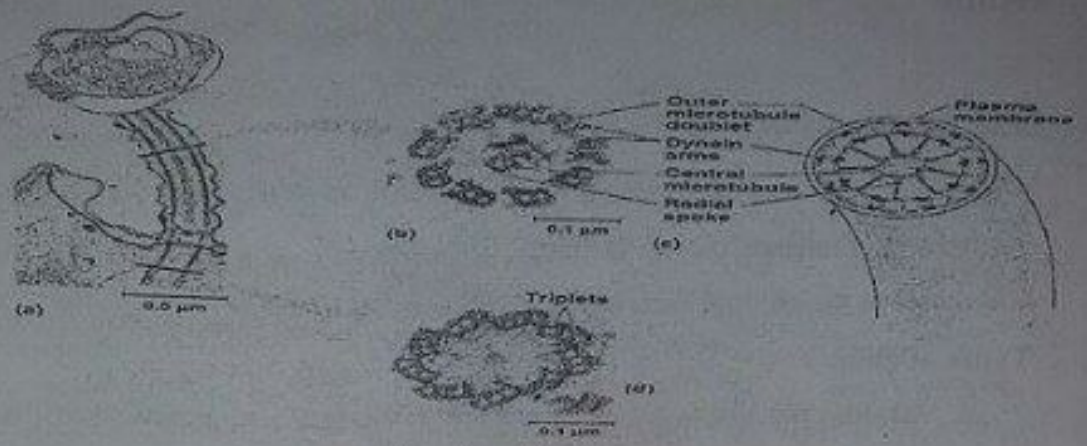
1-Coordinated movements of cilia produce movement of fluids, and particles across cell membrane.

Ex: movement of mucus and trapped particles away from respiratory tract and toward the throat.

- Damage to cilia (excessive smoking) will reduce "cleansing," leading to chronic respiratory infections.

2- cilia act as a sensory antenna for the cell, receiving signals from other cells or fluids nearby.

5-
1-
2-
3-
4-
5-



Structure of the cilia

5-Flagella

Resemble cilia but much longer.

Responsible for moving the cell (ex: sperm cell).

So nonmembranous organelles can be listed as follow:

1-Ribosomes

2-Cytoskeleton

3-Centrosomes and Centrioles

4-Cilia

5-Flagella